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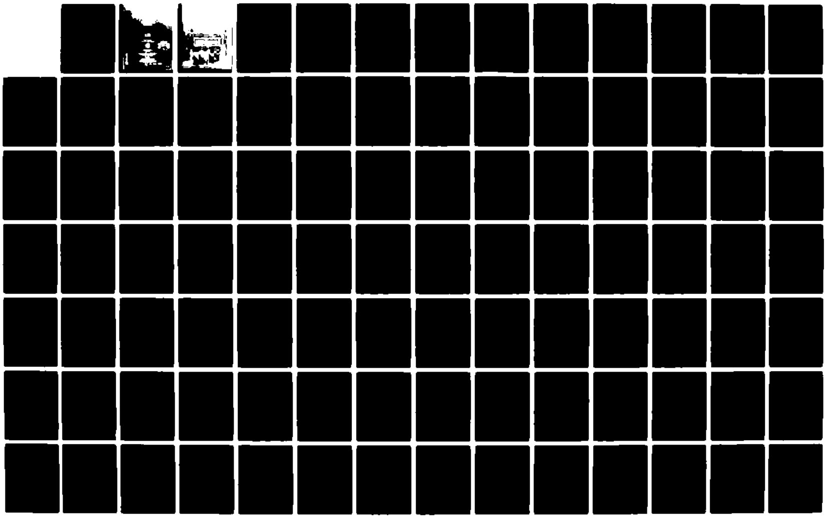

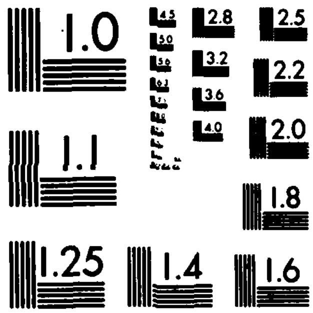

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16. Abstract

The Oceanic (and selected Non-Oceanic) Area System Improvement Study (OASIS), conducted by SRI International under contract with the Federal Aviation Administration (FAA), was part of a broad oceanic aeronautical system improvement study program coordinated by the "Committee to Review the Application of Satellite and Other Techniques to Civil Aviation" (also called the Aviation Review Committee or the ARC). The OASIS Project, with inputs from the international aviation community, examined current and potential future oceanic air traffic control (ATC) systems in the North Atlantic (NAT), Central East Pacific (CEP), and Caribbean (CAR) regions. This phase of the Aviation Review Committee program began in late-1978 and was completed in mid-1981.

The thrust of the Aviation Review Committee program, which OASIS broadly supported, was to analyze the present ATC systems; examine future system requirements; identify areas where the present systems might be improved; and develop and analyze potential system improvement options. The time frame of this study is the period 1979 to 2005.

This report describes the functional and logical structure of the Flight Cost Model (FCM) computer program modules which were developed to simulate air traffic operations in oceanic areas. The FCM modules include the: network generating routine, track setting routine, meteorology routine, flight planning model (FPM), flight tracking model (FTM) and report generating package. The organization of each and the interrelation between these programs are addressed in the report.

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Oceanic Area System Improvement Study (OASIS)

Final Report

This report is one of a set of companion documents which includes the following volumes:

Volume I
Executive Summary and Improvement Alternatives Development and Analysis

Volume II
North Atlantic Region Air Traffic Services System Description

Volume III
Central East Pacific Region Air Traffic Services System Description

Volume IV
Caribbean Region Air Traffic Services System Description

Volume V
North Atlantic, Central East Pacific, and Caribbean Regions Communication Systems Description

Volume VI
North Atlantic, Central East Pacific, and Caribbean Regions Navigation Systems Description

Volume VII
North Atlantic Region Flight Cost Model Results

Volume VIII
Central East Pacific Region Flight Cost Model Results

Volume IX
Flight Cost Model Description

Volume X
North Atlantic, Central East Pacific, and Caribbean Regions Aviation Traffic Forecasts

PREFACE

The Oceanic Area System Improvement Study (OASIS) was conducted in coordination with the "Committee to Review the Application of Satellite and Other Techniques to Civil Aviation (also called the Aviation Review Committee or the ARC)." This study examined the operational, technological, and economic aspects of the current and proposed future oceanic air traffic systems in the North Atlantic (NAT), Caribbean (CAR), and Central East Pacific (CEP) regions and assessed the relative merits of alternative improvement options. A key requirement of this study was to develop a detailed description of the present air traffic system. In support of this requirement, and in cooperation with working groups of the Committee, questionnaires were distributed to the providers and users of the oceanic air traffic systems. Responses to these questionnaires, special reports prepared by system provider organizations, other publications, and field observations made by the OASIS staff were the basis for the systems descriptions presented in this report. The descriptions also were based on information obtained during Working Group A and B meetings and workshops sponsored by Working Group A. The information given in this report documents the state of the oceanic air traffic system in mid 1979.

In the course of the work valuable contributions, advice, data, and opinions were received from a number of sources both in the United States and outside it. Valuable information and guidance were received and utilized from the International Civil Aviaiton Organization (ICAO), the North Atlantic Systems Planning Group (NAT/SPG), the North Atlantic Traffic Forecast Group (NAT/TFG), several administrations, the International Air Transport Association (IATA), the airlines, the International Federation of Airline Pilots Association (IFALPA), other aviation associated organizations, and especially from the "Committee to Review the Application of Satellite and Other Techniques to Civil Aviation."

It is understood of course, and should be noted, that participation in this work or contribution to it does not imply either endorsement or agreement to the findings by any contributors or policy agreement by any administration which graciously chose to contribute.

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EXECUTIVE SUMMARY

Flight Cost Model (FCM)

The FCM, a set of computer sub-models developed by SRI for the FAA, simulates air traffic operations in a large-scale airspace region. The FCM has been validated and used to model the North Atlantic and Central East Pacific oceanic airspaces. The FCM replicates the flight planning procedures used by airlines, ATC operating rules and conflict resolution strategies, meteorological conditions and aircraft flight performance characteristics in order to estimate flight time and fuel consumption experienced during climb, cruise (including step-climb) and descent operations. The FCM enables a means to estimate and compare the delay and diversion costs associated with various separation minima and operating procedures. FCM is capable of modeling:

- Domestic airspace routings
- Oceanic airspace including the Organised Track System (OTS)
- Multiple airports
- Aircraft characteristics (e.g. type, weight, and speed)
- Weather conditions
- Time-dependent flight segment restriction
- Multiple flight information regions (FIR) and control areas (CTA)
- Multiple levels of traffic control strategies classified according to domestic and oceanic (track or non-track) flight regions

The FCM modeling outputs include flight plans, a log of all simulation events and eleven simulation reports which includes planned and actual flight cost and time, instantaneous aircraft count and number of step climbs planned and cleared.

The FCM program includes six basic components:

- Network Generating Routine
- Track Setting Routine
- Weather Routine
- Flight Planning Model
- Flight Tracking Model
- Report Generating Package.

The Network Generating Routine aids in transforming the waypoints and flight segments of a given airspace into model entities. The Track Setting Routine lays down the specified tracks valid in a given time period. Temperature and wind conditions at the various flight levels on all flight segments are calculated by the Weather Routine using meteorological data including data provided daily by the U.S. Weather Bureau's National Meteorological Center (NMC) at Suitland, Maryland.

The Flight Planning Model determines three-dimensional minimum fuel (or cost or time) flight plan over the defined airspace for each flight in a flight schedule. A backward dynamic programming algorithm is used in the model with separate logic that determines the climb and descent profiles.

The Flight Tracking Model simulates the flight from origin airport to destination airport of each aircraft. Each flight is processed in accordance with the flight plan developed by the Flight Planning Model. When the flight path of an aircraft conflicts with the flight path reserved for another aircraft, the model will step through a list of diversion options until a conflict free flight path is determined and reserved. All events in the FTM simulation are recorded in a simulation log. This log is subsequently read by the Report Generating Package which produces eleven simulation reports.

ACKNOWLEDGEMENTS

We are highly appreciative of the guidance provided by the "Committee to Review the Application of Satellite and Other Techniques to Civil Aviation," particularly in regard to the support provided by Working Group A of the Committee (including the Working Group's rapporteur, Mr. J. Ruden) and to the Flight Cost Model Workshops sponsored by the Working Group. The authors gratefully acknowledge the assistance and cooperation of the FAA in completing this research project. The comments and suggestions of Mr. V. E. Foose, Mr. N. Craddock and Mr. J. Loos of the FAA were invaluable in contributing to the success of this effort.

This research was conducted by SRI International. Dr. George J. Couluris served as project leader. Project team members included Dr. John Bobick, Mr. Donato D'Esopo and Dr. Kai Wang. Dr. Bobick worked on the design and conceptualization of the model. Mr. D'Esopo programmed the traffic control strategies and report routines of the model. Dr. Wang worked on the weather routine, the flight planning routine, the data management, and the overall interface and coordination of the model. Ms. Geri Childs prepared this report. Dr. Robert S. Ratner and Mr. Joel R. Norman served as administrative supervisors.

1.0 INTRODUCTION

The Flight Cost Model (FCM) is a package of computer programs that determine the cost penalties of aircraft flying flight paths different from those desired in a given airspace. The airspace is a three-dimensional space where restricted airways such as North American Routes (e.g., NAR31) and the Organized Track System (OTS) in the North Atlantic region can be simulated. The programs are written in Simscript II.5 programming language. The block diagram of the FCM is given in Figure 1.

The model comprises two major modules, the Flight Planning Model (FPM) and the Flight Tracking Model (FTM), and four supporting modules. The Network Generating Routine (NGR) prepares a discrete network of potential flight paths segments in the airspace modelled. The Track Setting Routine (TSR) cordons off a corridor airspace and legalizes the appropriate flight levels in the network. TSR output is used by the Meteorology Routine (MET), which determines the headwind, crosswind, and temperature of every flight segment in the network. The input weather data are read from a magnetic tape supplied by the U.S. National Weather Service (NWS) at Suitland, Maryland. The FPM determines the minimum fuel flight paths for all flights in the flight schedule for a typical day. The FTM tries to assign each planned flight a flight path that is as close as possible to the one desired. The model mimics the functions of a human air traffic controller, using a prioritized list of control strategies and a set of separation standards. All events in the simulation are recorded in a simulation log. Using the information stored in the simulation log, the Report Generating Package (RGP) produces the required statistics in a printout.

1.1 Network Generating Routine

This module produces flight segments, known as links, which connect two waypoints in a defined waypoint grid network for the FCM. An airport is considered a waypoint in the present context. In the model, an aircraft can only move along a link. There are two component routines in the module. One duplicates domestic airways such as the North American Routes (NARS). The other generates links in the oceanic regions where there is no flight path restriction other than separation standards. The module provides as much flexibility as possible using present flow patterns determined from actual flight strips. Some regions have fewer links emanating from a waypoint (also called a node) than others. This is necessary to minimize computer core requirements and superfluous search effort during the flight path optimization process.

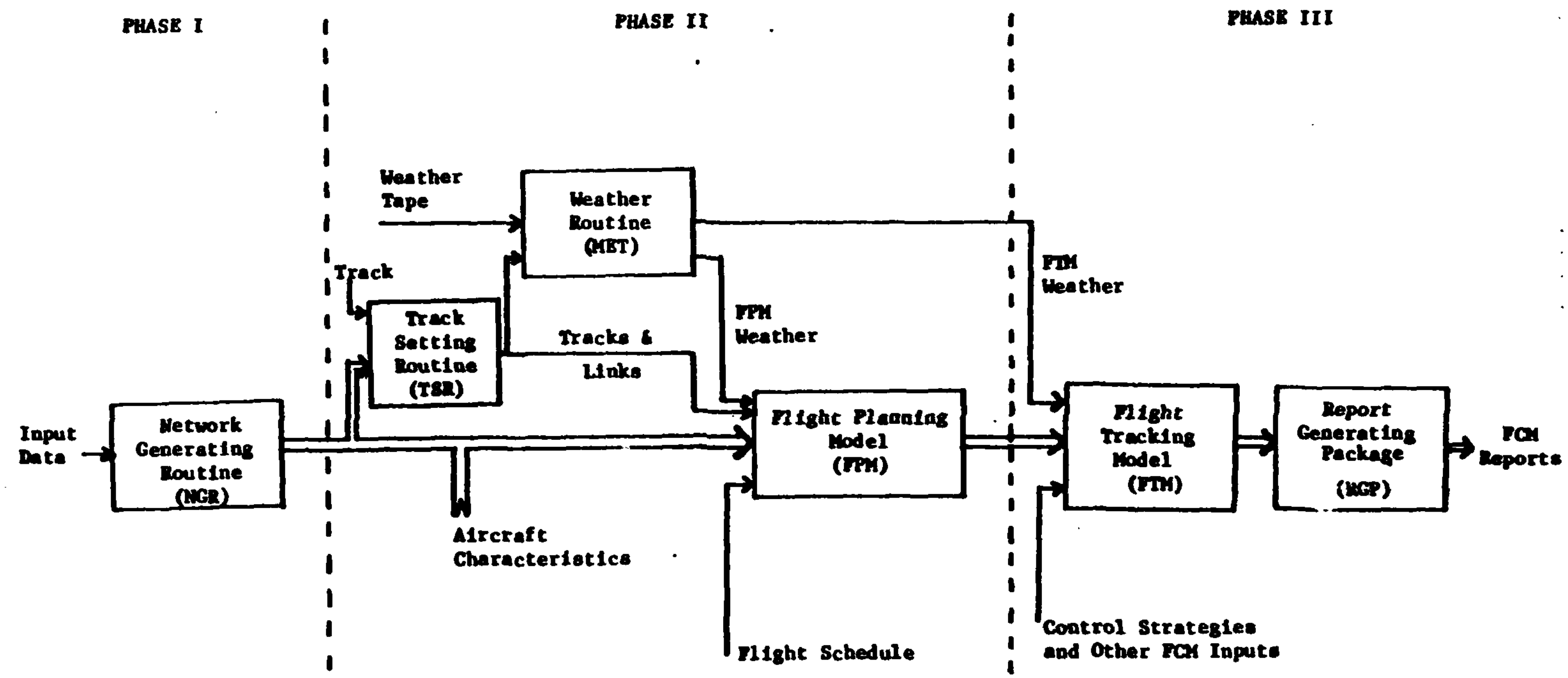


FIGURE 1 BLOCK DIAGRAM OF FLIGHT COST MODEL (FCM)

1.2 Track Setting Routine

This routine cordons off an air corridor with the proper flight levels along specific tracks to model the organized track system (OTS). Such systems exist in the North Atlantic (NAT) oceanic region and the Central East Pacific (CEP) oceanic region.

A track is defined by its waypoints and flight levels. The routine matches the links in the network to the waypoints of the track. When a match is found, the link is appropriately tagged and its flight levels reassigned. If no link exists to connect two consecutive waypoints of a track, a new link is created with the two waypoints as its end nodes and added to the link set of the track. Provisions are made to allow flights to join, leave, or move above and below the track system. Flights are not allowed to cross the track system at track flight levels. The output of the routine includes a graphic plot that facilitates trouble-shooting.

1.3 Meteorology Routine

The source of the meteorological data used by the FCM is the computer-produced forecasts from the U.S. Weather Bureau's National Meteorological Center at Suitland, Maryland. Suitland turns out two sets of forecasts per day, one set based on the 0000Z observations and the other based on the 1200Z observations. Each set of forecasts provides prognostic data for four validation times at 12, 18, 24, and 30 hours from observation time. For example, the forecasts based on 150000Z (15th day of the month) observations provide prognoses for validation times 151200Z, 151800Z, 160000Z, and 160600Z. These data are stored on magnetic tapes.

In the meteorology routine, the coordinates of a grid point are the latitude and longitude of the point. One or more regions (bounded by two meridians and two latitudes) are defined in the routine to cover the area where meteorological data are desired. These regions must be in the Northern Hemisphere. The routine extracts data from the weather tape for all grid points that fall in the defined regions. The regions must be defined within 0-20, 20-70, 70-80, or 80-90 degrees latitude as a result of changes inthe density of Suitland latitudinal data points. There are no longitudinal constraints on the regions.

The forecasts extracted from the weather tape describe four levels: 400 mb, 300 mb, 250 mb, and 200 mb. The data for each grid point consists of forecast winds (magnitude and direction) and temperatures for each of these levels. The wind vector is resolved into north-south and east-west wind components. The data set is then written on a computer disk file for subsequent use in FTM.

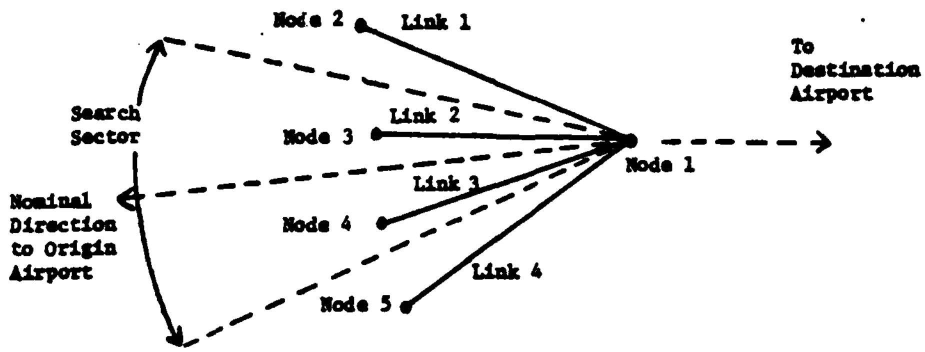
For each link of the network, the meteorological data are determined for the two end-points and for as many intermediate points as required by the length of the link. When any of these points fall outside the defined regions, zero wind and standard temperature are assumed. The headwind, crosswind, and temperature are determined for each of the link's legal flight levels. The resultant data set, which is flight-level dependent, is written into another disk file for use in FPM. Since there are two track-systems (east-bound and west-bound) per day in the NAT region, two FPM meteorological files are required. The same logic is used for each link in the FTM. In FTM, the link set is much smaller; only those links in the flight plans generated by the FPM or in the domestic airspace are defined.

1.4 Flight Planning Model

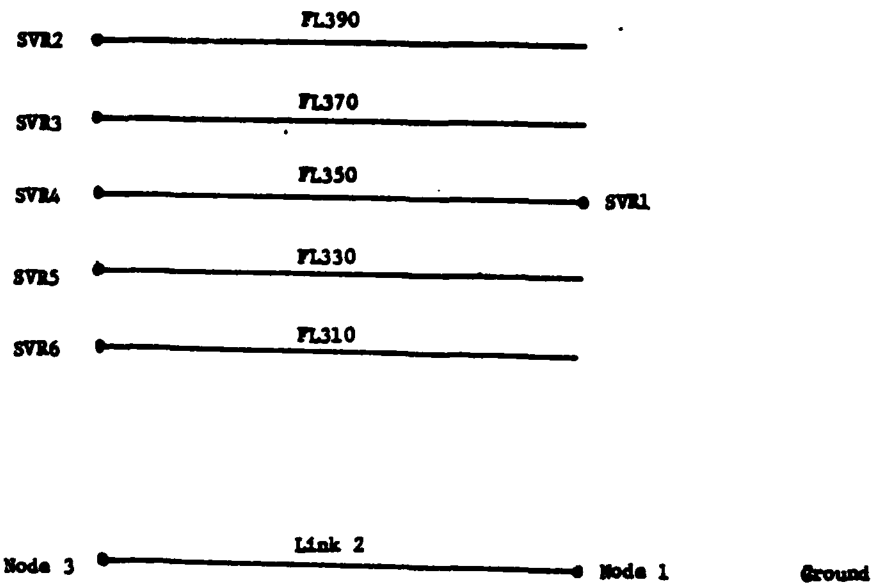
After the FPM is initiated, all information required by the model is stored compactly in core. The network of the study, including the track system, is defined. The associated weather file has been loaded. The characteristics of all aircraft used during the study, including new generation aircraft, are read. Aircraft data include ascent, descent, and cruise characteristics as well as landing gross weights for designated airport pairs. If the airport pair is undefined, a default value for the aircraft type is used. The module is driven by a one-day flight schedule. The departure time, arrival time, aircraft type, origin airport, destination airport, and other information are given for each flight in the schedule.

The planning model uses the backward dynamic programming technique to determine the optimal path from the origin airport to the destination airport. A minimum fuel criterion is used from any intermediate node to the destination airport. The optimization is done in a three-dimensional space as shown in Figure 2.

Suppose that at one instance during the optimization, the process is at SVR1 (State Variable Record 1), i.e., at Node 1 and FL350. SVR is both node and flight-level dependent. In the example, there are four links connecting Node 1 in the general direction of the origin airport. Only two of these fall within the search sector, which is determined by the nominal direction of the origin airport from Node 1 and a user-defined search angle. For each link in the sear sector (in this case Links 2 and 3), the cost of moving along the link each of the legal flight levels is determined. Figure 2.2 gives the vertical search pattern over Link 2, which has legal flight levels of FL310, FL330, FL350, FL370, and FL390. The cost of reaching SVR2 using, say, Link 2 and FL390 from SVR1 is compared with any previous best cost of reaching SVR2. The best-cost and other relevant data are updated at SVR2, if necessary.



2.1 Planar Projection of Search Pattern



2.2 Vertical Search Pattern Between Node 1 and Node 3 over Link 2

FIGURE 2 THREE-DIMENSIONAL SEARCH PATTERN OF THE DYNAMIC PROGRAMMING IN FPM

The search is paced by cost. The next SVR at which the above process is repeated will be the one with the least cost in the model. The search terminates when all feasible paths from the destination to the origin airport are traced. The model contains logic to handle the ascent and descent of the flight. The optimal flight plan is written into a disk file during the forward sweep of the algorithm. All domestic links or links that appear in a flight plan are flagged. At the end of the FPM, the set of all flagged links and other data are written into a second disk file for interfacing with the FTM.

As mentioned earlier, the model is driven by a flight schedule. This feature allows for easy restart of the FPM without wasting any work already done.

1.5 Flight Tracking Model

The FTM acts as a know-all air traffic controller in the airspace being modelled. It assigns flight paths, tracks all traffic, and resolves conflicts. It has knowledge of the domestic and oceanic airspace and allows for different separation standards in the two airspaces.

The following subsections describe in detail the logic of the model.

1.5.1 Takeoff Control

Using the scheduled departure time of each flight, the arrival time at the first node after reaching the cruise speed in the flight plan is determined. If a conflict exists, the departing flight is delayed on the ground until the conflict condition clears. The flight is then cleared and flown along the planned flight path to the first cruise node.

1.5.2 Flight Control

The flight control process is shown schematically in Figure 3 and described in the following discussion:

Upon reaching the first cruise node, and at each subsequent node, the clearance status of the aircraft is reviewed. If the aircraft is not cleared beyond the node at which it has arrived, a new clearance is required. This is obtained by a process that first determines the number of subsequent nodes through which the aircraft is to be cleared. In domestic airspace this is normally one node; at an ocean clearance or reclearance point, it is usually more than one. The same process also determines the flight level profile to be requested. Normally, the requested profile is the same as the planned profile. However, in the oceanic portions of the clearance range, the requested flight level is considered to be constant.

Next, the aircraft's present flight plan is tested to see if, for the extent of the clearance, the flight plan would violate separation rules concerning any flights previously cleared. This process is called conflict detection. If no conflicts are detected, the airspace required for the flight according to the plan is reserved for exclusive use of the flight.

If a conflict is detected, conflict resolution procedures are invoked to investigate alternate flight plans. This process consists of using a higher or lower altitude, with or without delays or rerouting, to find a plan that can be cleared. The cleared plan then replaces the original plan in future simulation of the flight. Should the conflict resolution process fail, the aircraft flies its original plan, without reserving the airspace, and thus not influencing clearances granted to other aircraft.

After the clearance status of the aircraft has been received and reviewed (if necessary), routines are called that determine the aircraft's time of arrival at the next node; further processing of the aircraft is suspended until that time.

Oceanic aircraft arriving at nodes at which reclearance is not required are checked to see if they are currently below their planned altitude. If so, a step climb procedure is called, which determines whether reclearance at the higher altitude (or at any legal altitude in between) would violate separation rules. If not, step climb to the highest such altitude is granted. Otherwise, the flight is continued at its current altitude.

For conflict detection, altitude changes granted in connection with step climbs, as well as those granted at the time of a clearance, are assumed to take place as the aircraft leaves the node. This simplification of real-world altitude change confines all uncertainty concerning aircraft altitude to a set of discrete locations--namely, the nodes of the network.

The processes used to analyze flight control logic are shown in Figure 3 and described in the following discussion.

1.5.3 Determination of the Range of Clearance and The Flight Level Profile to be Requested

If the aircraft is in domestic airspace and is not at an oceanic clearance request point or clearance delivery point, or is at the last such point prior to entering oceanic airspace, the range of the clearance is to the next node.

Otherwise, the general rule is that clearance extends through the remaining domestic portion of the flight (if any), through the flight information region (FIR) of oceanic entry (or the FIR that the aircraft is in), and up to the first point that does not belong to that FIR--or to the last oceanic point of the flight if that occurs first.

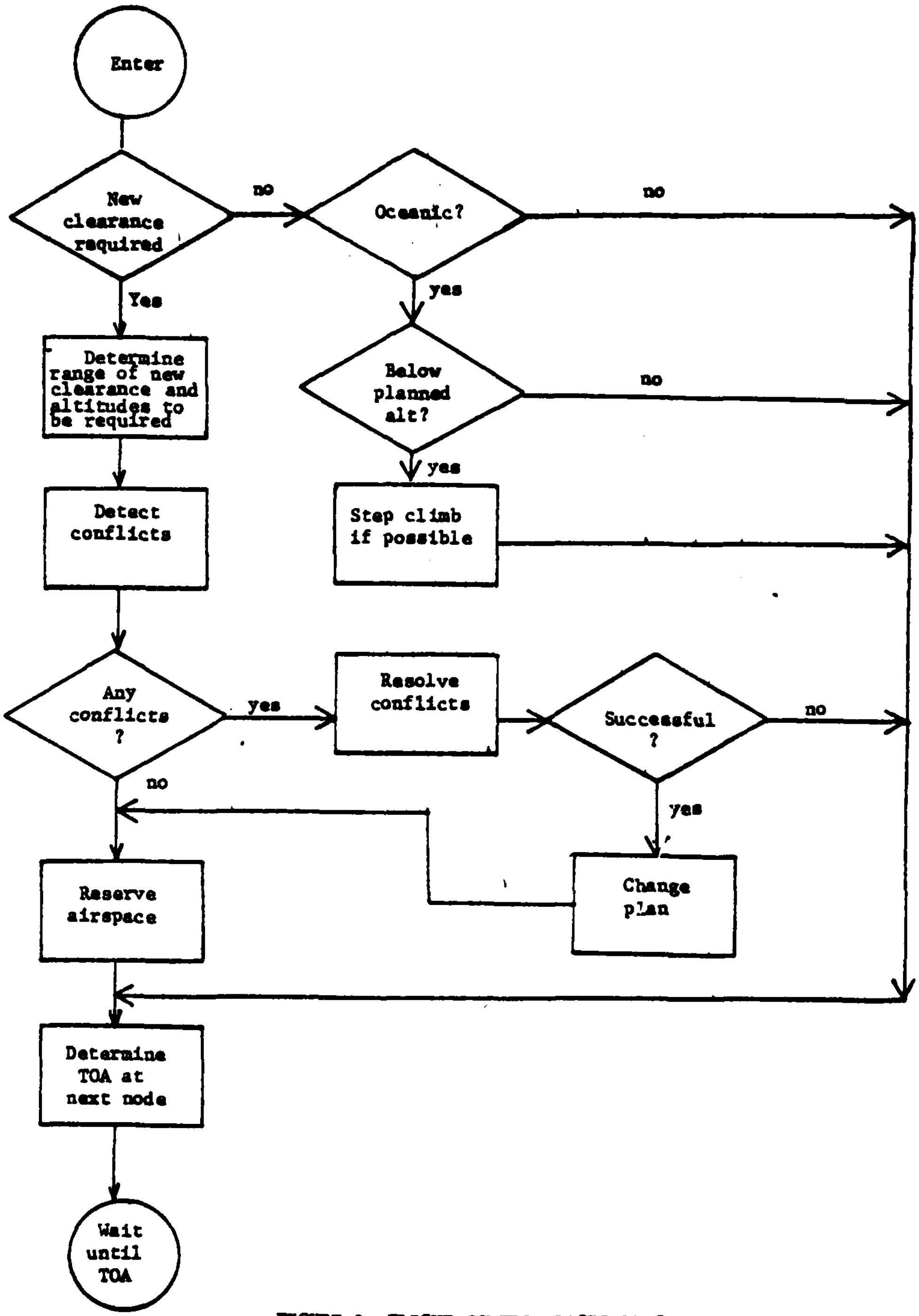


FIGURE 3 FLIGHT CONTROL LOGIC DIAGRAM

There are the following exceptions:

- Certain adjacent FIRs (such as Shanwick and Gander) are treated as a single FIR for the purpose of determining the range of clearance. The precise concept used in the program is that of Ocean Control Region (OCR), rather than FIR.

- Flights that enter oceanic airspace (or are recleared) at boundary points of OCRs are treated as being "in" the OCR that "owns" the most nodes that follow consecutively. This understanding maximizes the extent of the clearance.

- If the flight is an OTS flight, clearance extends to the last oceanic node of the track irrespective of OCR.

- If a flight enters and leaves the oceanic airspace in the same OCR, the clearance range includes the entire oceanic portion of the flight, even if some part of that flight leaves the OCR.

- If the flight has multiple oceanic segments, the segments are treated separately.

In domestic airspace, the requested flight level is the FPM-planned flight level, which may vary from link to link when the flight is to be cleared through multiple domestic nodes. In the oceanic portion of the flight, the flight level requested for initial clearance is the planned flight level in the first oceanic link; for reclearances, the higher level (of the planned link and current flight level) is requested. However, if this flight level is illegal on any link of the oceanic portion of the clearance, successively lower flight levels are tested until one is found that is legal throughout the oceanic portion of the clearance. Thus, the simulated procedure for requesting flight levels implements strategic clearance.

It should be noted that the method for simulating the oceanic clearance process simultaneously clears the remaining domestic portion of the flight plan as well. This amounts to modelling an approximation of the real-world situation where an aircraft's path through domestic airspace is cleared independently from, and possibly subsequent to, the oceanic clearance process. A real-world aircraft might be subject to congestion resulting in unanticipated delays, late arrival at the oceanic entry point, and a consequent need for reclearance. In contrast, the program determines a conflict-free path for simulated flights from the request point through domestic airspace to the oceanic entry point and through the remaining oceanic portion of the clearance range. In particular, congestion effects for simulated flights are worked out prior to determining the best available ocean pathway. This point is clarified below.

1.5.4 Conflict Detection

Conflicts between the part of a flight plan that falls within the clearance range and the cleared parts of other flight plans are identified in a two-step process. Step 1 examines pairs of flight plan segments to determine longitudinal and lateral separation, ignoring the vertical dimension. (A flight segment is the straight line portion of the flight plan between two consecutive nodes, its altitude, and entry and exit times. Conflicts in a segment include longitudinal conflicts at the exit node of the segment.) This step detects potential conflicts that would be actual conflicts if the aircraft were flying at the given altitude. A list of these potential conflicts is made for each segment, after considering all cleared segments of a comprehensive set of other aircraft. In Step 2 the list of potential conflicts is examined for altitude conflicts. This two-step process has an advantage: During conflict resolution, when an alternate plan involving only altitude change is investigated, only Step 2 needs to be performed.

Computer time required for Step 1 is reduced by limiting the flights and flight segments involved. The limitation is determined by applying the following selection rules to each segment of the clearance range (including the segment that the aircraft is just leaving):

- If the exit node, N, of the flight segment is in domestic airspace, conflicts of that segment or the following segment are considered to be possible only with those other cleared flight segments whose entry or exit node is also N. Thus, in domestic airspace, conflicts are considered to be possible only between aircraft whose paths intersect at a node, and then only immediately before or after the intersection. Lateral conflicts between nearby aircraft that are not approaching or leaving a common node are assumed to be resolved by domestic air traffic control (ATC) and the imposition of minor deviations in the courses of one or more of the aircraft.

- The same rule applies to OTS aircraft in oceanic airspace. It is assumed that OTS aircraft cannot be in lateral separation conflict unless they are on merging tracks.

- Where the first two rules do not apply (that is, to cleared oceanic segments of OTS aircraft vis-a-vis cleared oceanic segments of non-OTS aircraft, and to cleared segments of non-OTS aircraft vis-a-vis any cleared oceanic segment) the cleared segments of the other aircraft are considered as possibly conflicting only if they have either (1) a common node or (2) the same FIR. Thus, possible conflicts between nontouching flight segments that terminate in different FIRs are not recognized. However, tests showed that the number of such conflicts is on the order of one per thousand.

In determining whether there is a conflict between two flight segments, the following rules are applied:

- Longitudinal Separation--In oceanic airspace, aircraft whose courses merge at or prior to oceanic entry are subject to a system longitudinal separation criterion (e.g., 15 minutes). If, in addition, they have maintained a common and unvarying altitude since oceanic entry, the system separation criterion is relaxed when there is also a sufficient difference in Mach speed (e.g., 10 minutes if there is a Mach-speed difference of .03 or more, 5 minutes if .06 or more). The system separation criterion and the Mach-speed separation criteria are system inputs. Aircraft in domestic airspace or aircraft whose paths have merged or crossed are subject to a simultaneous time and distance separation rule that depends on the common node of the segments (e.g., 0 minutes and 5 miles in domestic air space, 20 minutes and 120 miles in oceanic airspace). Longitudinal separation is, of course, irrelevant to segments without a common node.

- Lateral Separation--The criterion for lateral separation is set equal to the smallest longitudinal separation distance required at any of the endpoints of the two flight segments (the longitudinal time criteria are not considered). The algorithm determines the minimum distance of any two aircraft in the segments. If the aircraft approach no closer than the lateral separation criterion distance, the lateral separation minimum is satisfied.

- Vertical Separation--Flight segments that fail to have longitudinal or lateral separation are required to have vertical separation. In the simple case that the aircraft do not change altitude at the entry or exit of either link, vertical separation is achieved if the flight levels are separated by at least 1,000 ft at or below 29,000 ft and by at least 2,000 ft above 29,000 ft. The critical altitude of 29,000 ft is actually an input. This input becomes 45,000 ft (the highest simulated flight level) for 1,000-ft separation cases. Even if aircraft change altitudes upon entering or exiting nearby links, separation will always be established if the highest flight level occupied by the lower aircraft is separated (as described) from the lowest flight level occupied by the higher aircraft. If this general rule cannot be satisfied, the following special rules are applied:

  - If the aircraft are not longitudinally separated at a node, they have vertical separation if (1) they are vertically separated (in the sense just described) upon departure from the node after any altitude changes and (2) when two aircraft arrive at the node at the same altitude or the higher arriving aircraft is also the higher departing one. This rule permits vertical separation to be achieved at the node by shifting the location of the altitude change to some unspecified point prior to reaching the common node.

- If aircraft are longitudinally separated at a common node, but fail to have lateral separation approaching or leaving the node, they are required to have vertical separation in the links in which the lateral separation fails.

- Aircraft in links that are not laterally separated are required to have vertical separation.

Scenarios can be found involving changes of altitude at a node that are permitted by the second or third vertical separation rule but are technicaly in violation of lateral separation as one of the aircraft passes through the flight level occupied by the other. These conflicts can be resolved with a method similar to that of the first Rule--that is, by moving the point of altitude change to some unspecified point in the link prior to the node.

A final point must be made concerning the way in which the conflict detection routines are used when oceanic clearance is obtained at a domestic point. In this case, the conflict detection routines are applied to each domestic segment sequentially. If conflicts are found in any of these segments, they are resolved (by the method decribed in the following subsection) prior to the next segment being analyzed for conflicts. Eventually, when the first oceanic segment is reached, it and all subsequent segments of the clearance range, plus any prior segments extending from the clearance delivery point to the ocean entry point, are treated as a single group for analysis of conflicts and subsequent conflict resolution. The prior segments will, of course, have had conflicts resolved by the sequential process in domestic airspace. Nevertheless, they are included in the range of the conflict detection and resolution analysis for purposes of applying certain conflict-resolution strategies.

1.5.5 Resolution of Conflicts

The conflict resolution routine is invoked following the detection of a conflict in a segment or group of segments in the clearance range. The routine operates in two modes--domestic and and oceanic. Except as noted below, it uses the domestic mode in the domestic segments within the clearance range of a flight plan. (A domestic segment has either one or both nodes in domestic airspace.) In the domestic case, the links are treated separately and in sequence. When an oceanic segment exists within the clearance range, the routine is applied to that segment, all previous segments in the clearance range, and also all links (if any) between the clearance delivery point and the oceanic entry (even though conflicts in these links have already been resolved by prior application of the resolution routines in the domestic mode). These additional domestic links play a role in delays, diversions, and Mach changes as described below.

In either mode, the general approach is the same; a sequence of conflict resolution strategies is investigated. Each strategy develops a unique modification of the flight plan. The modified flight plan is tested for conflicts; if none are found, the process terminates. Otherwise, the next conflict resolution strategy is applied. It is possible that none of the strategies will yield a conflict-free flight plan. Should this be the case, the routine will "give up" and direct the flight according to its original flight plan. A sample sequence of conflict resolution strategies for NAS is given in Appendix A.

The sequence of strategies employed to resolve a conflict in a segment or group of segments depends on the entry node of the segment (or first segment) and whether the mode of resolution is domestic or oceanic. Each strategy has certain "specified quantities," or inputs. The same strategy can occur in the sequence several different times, each occurrence being associated with different specified quantities. For example, a delay of up to 2 minutes will occur earlier in a sequence than a delay of up to 5 minutes.

The following brief outline gives the various strategies in tabular form:

Strategy Type	Strategy Name	Method for Developing Flight Plan Alternative
Domestic	Climb	Check successive flight levels above planned flight level for directional legality, weight feasibility, and conflicts. Set new flight level to the first legal, feasible, conflict-free flight level. Also, raise to this level any lower flight levels in subsequent links of the clearance range.
	Descend	Same as climb, except check only one flight level below planned flight level. Also, lower only the flight level of the conflicted link, not the remaining links of the clearance range.
	Delay	If conflict is longitudinal, slow aircraft by not more than a specified amount to fit its arrival at the node of conflict into a gap after the conflicting aircraft or after one or more aircraft following the conflicting aircraft. If conflict is not longitudinal, use the original flight plan.

Oceanic	Climb	Ascend a specified number of separation levels from the current level, provided the resulting level is legal in the desired direction throughout the clearance range and the aircraft is light enough. (A separation level is 1,000 or 2,000 ft, depending on the aircraft's current altitude.) The climb location can be "strategic," i.e., at the oceanic entry node (or even prior to it if possible) or, if a reclearance, at the current node, or "tactical," i.e., one node prior to the conflict. Whether the strategic or tactical method is employed depends on the FIR that the aircraft is entering, or, for reclearance, the FIR that it is in.
	Descend	Similar to climb, except the strategic method never descends prior to ocean entry.
	Delay	Delay aircraft up to a specified maximum amount and alter flight level a specified number of separation levels. Method is similar to domestic delay, except that instead of giving up when gap cannot be found between adjacent aircraft at the longitudinal conflict node, the method "tries blindly," i.e., constructs a series of increasingly delayed flight plans (two in NAT and five in CEP) and tests each for conflicts. This approach is used if (1) the gap method is inapplicable to lateral conflicts and (2) the complex rules for determining longitudinal separation time requirements, i.e., the gap size, are not fully encoded in the method, so that it occasionally fails to find a gap even when one exists. (In CEP the gap method is skipped entirely.)
	Alter track	Construct a flight plan at the current planned altitude plus a specified number of 1,000-ft increments and divert a specified number of tracks away from the current track. Divert from the clearance delivery point via a great-circle path to the first oceanic node of the new track. Route to destination via a great-circle route from the last ocean node of the new track to a landfall and from the designated route to the airport. Choose a landfall that will minimize the distance travelled.

Change Mach	Change Mach by a specified (usually negative) amount. Adjust arrival times in proportion to change. Mach change starts in first link subsequent to the clearance delivery point when appropriate.

1.5.6 Step Climb Logic

Step climb logic is applied each time an aircraft arrives at a node that is within its most recently determined clearance range and when the currently assigned altitude in the following link is below the desired flight level. The procedure uses the conflict detection routine to attempt to clear the flight throughout the remainder of the range at the desired level, assuming the current schedule of arrival times at subsequent nodes is correct. If this fails, successively lower flight levels are checked in a similar way. Weight feasability is checked, too, because the aircraft may be heavier at the node (due to diversions or wind conditions) than FPM planned for.

1.5.7 Flight Time Determination

To detect and resolve conflicts, a time-phased schedule of arrivals at the successive nodes must be developed. The flight time determination routine, invoked while the clearance range is being determined, performs these calculations. This routine is also called to determine the arrival times for track diversions.

Finally, when the aircraft has actually flown to the next node, the flight time determination routine determines the time of arrival at the next node. In this last application, if a step climb has been completed, the routine assumes that a specified (input) amount of step climb reaction time is spent at the lower altitude prior to attainment of the new altitude.

The routine determines fuel burn as well as flight time and, except for the treatment of step climb, is logically equivalent to the corresponding FPM routine.

1.6 Landing Control

For a flight that has not been diverted, the descent profile is given in the flight plan. Otherwise, the model will determine the descent profile for that flight. Upon leaving the last node before descent, the plane will be flown conflict-free en route to the airport. Airport congestion is not considered.

After landing, the vital statistics of the flight, such as fuel burned and time of flight, are written in the simulation log.

2.0 FCM STRUCTURE

The structural design of FCM, especially the FTM, is greatly influenced by the structure of the SIMSCRIPT II.5 computer language in which it is coded. Within the language are structural elements called entities. A model entity may correspond to a real-world object or process, or it may be a modeling artifact to facilitate the coding of logic. An entity may be classed according to the duration of its existence. A permanent entity exists for the duration of the model's run. A temporary entity will exist as long as it is needed and will be destroyed when it is not. An entity may have attributes. These attributes define the entity. An attribute may be a physical characteristic or parameter, a descriptor of the state of the entity, or information pertaining to the internal logic of the model.

Another structural element in the SIMSCRIPT language is called an event. Events are time-dependent occurrences that control the flow of logic within the simulation. These events may be external or internal. External events are those that are directly controlled by the user of a model via input data. Internal events are those generated within the model as a result of the programmed logic. The SIMSCRIPT timing routine and event processor automatically keep track of pending events, advance the simulation clock, and execute the event that is due to occur next. The execution of an event involves the exercise of some model logic. This may include exercising model routines, updating the values of the attributes of entities, scheduling additional events, cancelling pending events, and so on.

In the remainder of this section, the entities, attributes, and events of FPM and FTM will be discussed. The entities of the NGR, TSR, and MET modules are in common with those of FPM. This discussion is useful because it demonstrates how physical objects, processes, and parameters are represented in the FPM and the FTM simulation. It also describes the level of detail at which the logic operates, the sensitivity of FCM to various parameters, the control and flow of logic, and the real-world events that the model is designed to handle.

2.1 Simulation Entities

The major permanent entities for NGR, TSR, MET, FPM and FTM include:

- o NODE
- o LINK
- o ROUTE
- o TRACK

- INLAND.FIX
- AIRPORT
- AC.TYPE
- MACH LEVEL.

In addition, FPM has these permanent entities:

- RHUMB.SECTOR
- S.V.R
- INTERVAL

Instead of these, FTM has the following additional permanent entities:

- CK.AC
- NODE.CLASS
- FIR.

FTM also has the following temporary entities:

- AIRCRAFT
- FLT.STRIP
- PTL.CONFL
- MCH.RLTN.

Brief descriptions of these entities and some of their associated attributes (i.e., descriptive parameters) follow.

2.1.1 NODE

A NODE designates a point on the ground (Figure 2.2) by its latitudinal and longitudinal attributes. It may correspond to a navigational fix (VOR, marker, or intersection) or an airport in a domestic control region. Over the oceanic control region, a uniform node grid is defined. Altitude or direction change can be performed only at a NODE. A NODE may be connected to as many other NODES as required, each by a LINK. Other attributes of a NODE indicate whether it is an airport and where a plane may be diverted if requested.

In FPM, the dynamic program progresses from NODE to NODE. In FPM, therefore, NODES have several parameters describing their current state in this process.

In FTM, a NODE has a different subset of attributes. These attributes identify the control region to which the NODE belongs and the attendant separation standard for airplanes converging to or diverging from the NODE. The flight information regions (FIRs) to which the NODE belongs are given. The attributes also identify whether the NODE is a clearance request point, clearance delivery point, both of the above, or none of the above. Furthermore, a NODE has a list associated with it in which flight strips of aircraft using the Node can be filed and time-ordered. Using this list, any conflict at the NODE is readily identified.

2.1.2 LINK

A LINK is a ground path connecting the from-node of the LINK to its to-node. It has a great-circle distance measured in nautical miles and a rhumb line heading measured from the geographic north. The heading is determined by the direction of travel from the from-node to the to-node of the LINK. This heading is used to determine the headwind and cross-wind of the flight levels over the LINK. An attribute of the LINK points to one of the entries of a flight-level table. This entry determines the legal flight levels and the flight directions of these flight levels over the LINK. Another attribute identifies the general east-west heading of the LINK.

In the FPM, a LINK is further defined in terms of three other parameters: the rhumb line sector to which it belongs, the route flag, and the flight plan flag. The sector number identifies which specific rhumb line sector the LINK falls within (discussed in the sector sub-section). The track flag is set high if the LINK is a member of a track in the track system currently in effect or a member of domestic routes. This facilitates the optimization search of a flight constrained to the track system. The flight plan flag is set for any LINK that is a member of domestic routes or a track system or has ever been used in a flight plan. As more and more flights are planned, this link set will grow. At the end of the planning procedure, only those LINKS belonging to this set are transferred to the FTM.

2.1.3 ROUTE

A ROUTE is an ordered set of LINKS that models an actual airway such as NAR-21 or A-15. The origin NODE of a ROUTE is the from-node of the first LINK; its destination NODE is the to-node of the last Link. (LINKS in ROUTES must be one-directional.) A ROUTE has a specific travel direction. All aircraft on a ROUTE must travel along the direction from its origin to its destination NODE. Hence, ROUTES are classified into four subsets: from-route, to-route, inbound-route, and outbound-route. The origin NODE of a from-route and an outbound-route must be an AIRPORT and an INLAND.FIX respectively. Similarly, the destination NODE of a to-route and an inbound-route must be an AIRPORT and an INLAND.FIX respectively. There are no restrictions on the end NODES of ROUTES not so specified above. Thus, if an airway allows bidirectional travel, two ROUTES have to be defined. The ROUTE concept is used in the ascent and descent phases of flight planning. During climb and descent, an aircraft must follow a specific ROUTE once the ROUTE is selected. ROUTE definition also allows specification of aircraft rerouting after a TRACK diversion.

2.1.4 TRACK

A TRACK is an ordered sequence of LINKS with two end NODES. It models an actual track in the Organized Track System (OTS) in the North Atlantic and in the Central East Pacific. Unlike a ROUTE there is no restriction on its end NODES and on the direction of travel on the TRACK. Once an aircraft gets onto a TRACk, it must stay on the TRACK for the entire length of the TRACK with the exception of the northernmost or the southernmost TRACK. Step climbs along a TRACK are permitted.

Two or more TRACKS constitute a TRACK system. The airspace bound by the TRACK system is restricted where reduced separation standards between aircraft apply. TRACK crossings are allowed only at flight levels above and below the flight levels of the TRACK system.

2.1.5 INLAND.FIX

INLAND.FIXES are the beginnings and the ends of domestic routings for oceanic traffic. In CEP, the INLAND.FIX entity is used to reduce the total number of ROUTES that have to be defined. In which case, it is a NODE typically located at the intersection of airways.

2.1.6 AIRPORT

Each AIRPORT has an alphanumeric identifier and a node identifier. It serves as a sink and a source for aircraft flying in the system. The prices of such consumables as fuel are those given in the attribute list of the origin AIRPORT. The runway taxi times for both arriving and departing flights are attributes of the AIRPORT as well. An AIRPORT anchors a set of from-routes and a set of to-routes. These are the paths that an aircraft must follow during ascent and descent, respectively.

2.1.7 AC.TYPE

The attributes of an AC.TYPE include an alphanumeric identifier, the various aircraft characteristics, and the hourly cost of flying the aircraft type.

Present and future generations of air transports, including general aviation aircraft, are used in the simulation. Associated with each AC.TYPE is a list of Mach speeds the plane will be flying, a step-climb fuel-burn table, a descent time table, a descent distance table, and a descent fuel-burn table of the aircraft. Step climb fuel burn is a function of step climb alone. The descent tables are weight and altitude dependent.

2.1.8 MACH.LEVEL

MACH.LEVEL is an entity created to facilitate the storage of aircraft characteristics at different Mach speeds of the aircraft. For each aircraft type, a MACH.LEVEL is assigned to each Mach speed of that type. That is, if there are eight aircraft types and each type has three Mach speeds, a total of 24 MACH.LEVELS are required. The characteristics stored per MACH.LEVEL are the true airspeed (TAS), the ceiling weight, ascent time, ascent fuel, ascent distance and cruise fuel burn of the aircraft at that Mach speed. TAS is a function of altitude, ceiling weight is a function of altitude and temperature and the other characteristics are functions of altitude and weight at the given Mach speed.

2.1.9 RHUMB.SECTOR

The RHUMB.SECTOR entity in FPM allows the network of the model to be divided into sectors by longitude. Each LINK in the model is assigned a sector according to the longitude of its midpoint. For each flight in the schedule, the nominal rhumb line headings of the great-circle path in the sectors between the origin- destination airport pair are determined. During the search, any LINK whose heading deviates from flight path in the sector by a given amount will be rejected. This will eliminate unnecessary search effort and reduce the cost of the flight planning process.

2.1.10 S.V.R

S.V.R is the acronym for State Variable Record. At each node of the network, there is a pointer associated with each global flight level. This pointer will identify the S.V.R in which are stored the cost, weight, and time of the flight currently being planned by the FPM upon reaching a given node at a given flight level. The S.V.R has other attributes that identify the LINK, the next NODE, and the next flight level along the optimal flight path starting from the NODE at a particular altitude. The cost figure of the S.V.R determines the list where the S.V.R will be filed. S.V.R lists are ranked by cost; S.V.R with the lowest cost is the first on the list.

2.1.11 INTERVAL

An INTERVAL has a S.V.R list associated with it. The interval that an S.V.R belongs to depends on the cost figure of the S.V.R. In the optimization process, the algorithm starts with the first entry in the S.V.R list in the lowest INTERVAL. When the list in the INTERVAL is exhausted, the algorithm will proceed to the next highest INTERVAL and so on until there are no more entries in any of the INTERVALS. Thus, the entity feature of the language greatly influences the design of the FPM.

2.1.12 CK.AC

A CK.AC is an entity that aids the development of alternative flight plans for an aircraft. It has an aircraft pointer, a pointer to the flight strip where conflict occurs, a code that describes the nature of the conflict, and other parameters that are used in the diversion of the aircraft if diversion is required.

2.1.13 NODE.CLASS

This entity permits classification of NODES by means of the separation standards at the NODES. Typically NODES fall into one of these classes: domestic, oceanic-track, and oceanic-nontrack. The attributes of each NODE.CLASS include the distance and time separation standards for planes traveling in trail as well as planes traveling on different LINKS converging on or diverging from a NODE in the NODE.CLASS.

2.1.14 FIR

This entity is defined to include all network NODES that fall within a Flight Information Region. Each FIR has an alphanumeric identifier and keeps an instantaneous count of the total number of aircraft within the FIR. The instantaneous aircraft count of each FIR is written periodically into the simulation log. Whether tactical or strategic conflict resolution is applied to a given conflict depends on the FIR where the conflict is resolved.

2.1.15 AIRCRAFT

An AIRCRAFT entity represents a flight aircraft in the FTM. This entity is created when the flight is read from the flight plan file and destroyed after the aircraft has landed at the destination airport. Thus, the number of aircraft in the system is governed by the time-sequence events of takeoffs and landings in the system. Each AIRCRAFT has a carrier name, a flight number, an AIRCRAFT type name, an origin airport, and a destination airport. Planned and actual flight information such as flight time, flight cost, and flight fuel burn are stored in the attributes of the AIRCRAFT. Each AIRCRAFT has additional parameters that describe the current position, flight strip, and progress in the system.

2.1.16 FLT.STRIP

The FLT.STRIP entity is used to record current flight plan and to reserve a flight. FLT.STRIPS for a flight are created when the flight enters the simulation (by external event FLIGHT) and destroyed when the flight leaves the simulation (by internal event LANDING). For each flight, the conflict conditions are checked at every NODE by comparing its FLT.STRIPS with those of other aircraft that are filed in NODE

FLT.STRIP lists. When a flight is cleared at the NODE, the corresponding flight strip is filed at the NODE. Filing the flight strip at the NODE reserves the airspace to ensure safe passage of the flight at the time it passes over the NODE. Any other aircraft wishing to pass over the NODE must check the flight strips filed at the NODE and at other nearby nodes. Clearance is given on a first-come-first-served basis. The attributes of a FLT.STRIP include an AIRCRAFT pointer, a NODE pointer, a LINK pointer that identifies the LINK used leaving the NODE, and pointers that identify the desired and actual altitudes used in departing from the NODE. Other parameters give the weight, the estimated time of arrival (ETA), and the Mach speed of the flight. Potential conflicts are also identified and filed in a list associated with each flight strip.

2.1.17 PTL.CONFL

The PTL.CONFL entity identifies a potential conflict of an AIRCRAFT at a NODE. It has a pointer that identifies the flight strip where the conflict occurs and a code identifying the type of conflict.

2.1.18 MCH.RLTN

This entity is used to encode the relationship between two aircraft that permits reduced longitudinal separations. If an aircraft enters oceanic airspace and thereafter follows the same path as an aircraft whose clearance is being attempted, a MCH.RLTN is created and filed in a list associated with the subject aircraft. The MCH.RLTD.AC of the MCH.RLTN is set to point at the other aircraft. Moreover, if a special headway rule (e.g., 5 minutes) applies due to Mach speed difference between the aircraft, the attribute MR.ALT is set at the altitude of entry of the other aircraft. This altitude is used in CHK.ALT to check whether longitudinal separation is established (so that vertical separation is not required).

2.2 Simulation Events

External events allow the user to control the flow of the program logic via input data. At any time during the simulation the user can designate an external event to occur. The external events of FPM include:

- SET.PATHS
- MET.UPDATE
- END.SIMULATION.

Those of FTM include:

- SET.PATHS
- MET.UPDATE
- FLIGHT.

The SET.PATHS and MET.UPDATE in FPM and FTM are similar in function and will be described together in the general description of events. There are also internal events, which are scheduled by the internal simulation logic. These are more closely associated with the simulation logic and are described in a latter section of this report.

2.2.1 SET.PATHS

The SET.PATHS event allows the user to specify the legal links and routes in the network at any specific time. Thus, the user can readily simulate the closing of a certain route for a given period if so desired taking care that the same event must be scheduled at the same simulation time in both FPM and FTM.

2.2.2 MET.UPDATE

The MET.UPDATE event provides the user with the capability to update the meteorological data of all links in the system at any time during the simulation. The event will cause a new set of precalculated weather prognoses to be loaded. These data files have been prepared using the NGR and MET routines (Figure 1).

2.2.3 END.SIMULATION

This FPM event correctly terminates the FPM run and writes and closes all output data files. This event should be the last event of the FPM model run.

2.2.4 FLIGHT

The FPM generates a time-sequenced flight plan in an output file. Each flight plan becomes an external event in the FTM at the scheduled departure time of the flight. At the event time of FLIGHT, the FTM traffic controller will schedule an aircraft requesting takeoff at the origin airport of the flight. This process is the means for adding aircraft to the system during the FTM model run.

3.0 FCM PROGRAM LOGIC

A list of the routines of the six FCM modules and a brief description of each is given in the following subsections. Flow charts of the program logic are given where appropriate.

3.1 Network Generating Routine

This module has two component routines: the Oceanic Network and the Domestic Network.

3.1.1 Oceanic Network

Program Description

The input to this program is a set of user-defined nodes and links. In the oceanic regions, the nodes are distributed uniformly along a longitude. For example, there is a column of oceanic nodes at 50 degrees West longitude, another at 60 degrees West longitude, and so on in the North Atlantic region. The separation of nodes along a longitude corresponds to the shortest lateral separation standard that is envisioned. Other nodes that may correspond to navigation fixes can also be defined. The link specifications are derived using the traffic flow pattern of present-day traffic.

The program assigns a number to each node and creates a link for every node-pair specified in the input. The network can be printed for verification. A data file is created for subsequent use.

Definition of Routines

ASSIGN.NODE assigns a number to each node specified in the input and sets up data arrays used later in link creation.

LAND.LINK generates links connecting a random node to a given number of nodes on the uniform node grid system. A random node is one that does not belong to the uniform grid system.

LINK.REPORT prints the links generated by the program in a readily readable format for decoding purposes.

MAIN controls the execution sequence of the program. It reads all the input data and calls the appropriate routines to create the link network and print the output. It closes all output files and terminates the program.

NODE.REPORT prints the nodes of the network in a readily readable format.

OCEAN.LINK generates links connecting each pair of ocean nodes as specified in the input.

PREAMBLE, a SIMSCRIPT module, defines the arrays and variables that are common to all routines of the Oceanic Network program.

SAVE.DISK2 writes the node and link data in card image format in the output data file. The input keywords are NODES and LINKS, which are written preceding the listing of node and link data, respectively.

3.1.2 Domestic Network

Program Description

This program completes the simulation network generated by the previous program. From a specific formatted list of input, the nodes, links, and routes of the domestic network are generated. The complete network is obtained by using the system text editor to combine the outputs of these two programs.

Definition of Routines

PREAMBLE, a SIMSCRIPT module, defines the structure of the Domestic Network program. It defines the entities, attributes, variables, and arrays used in the MAIN routine, which is the only routine of the program.

MAIN reads in the first domestic node number and the first domestic link number. The input keywords are FIXES, LINKS, ROUTES, and FEEDERS. The routine will assign a sequential node number to all the fixes and generate all the links as specified by link and route specifications. Feeders are short routes, each of which connects an airport and a fix with a single link.

3.2 Track Setting Routine

3.2.1 Program Description

This program determines which network links are members of a track setting and sets their flight levels accordingly. The networks are read in via input data sets. Tracks are specified by a sequence of waypoint nodes given in terms of latitude, longitude, and the flight levels of the given track.

For each track setting (there may be two for each day) the following steps are performed sequentially. The nodes that are members of the tracks are determined by matching the coordinates of the waypoints with those of the system nodes. Depending on their positions with respect to the track setting, all nodes are then tagged as being within-track, north-of-track, and south-of-track. Using this information, the links that are members of the tracks are determined. If track specifications include a link that is not in the network, that link will be created and added to the network. The flight levels of these links and all other track-related links are set. Track-related links are those with one of their end-nodes bounded by the northern-most and southern-most tracks or lying on any track. A link data set and its proper flight levels are written in a data file. A graphical plot of the track setting is produced. The network is then reset for the next track setting.

After all track settings are completed, a link and track data file will be written.

3.2.2 Definition of Routines

ADD.LINK adds a track's newly created link to the link array associated with the given node.

CONVERT, a function routine, converts a coordinate given in DEGREE.MINUTE format to decimal degrees.

GCPLOT, a function routine, returns the latitude of a point on a given track that has the same longitude as the given point. This allows the north-south position of the given point to be determined with respect to the given track.

IN.PROC reads in the system network from the input data file. The input is paced by keywords such as NODES, LINKS, ROUTES, TRACK, ALTITUDES, OTHERS and GO. When the keyword GO is encountered, all input data have been successfully processed and stored.

LINKAGE determines the links that are connected to each node in the network and stores them in an array associated with the node.

LNK.TRK.WRT writes the output linkand track-data file.

LNK.WRT writes a link data file for intermediate storage.

LVL.REPROC uses the final link set to rewrite the output flight levels file.

MAIN calls the routines sequentially to read the input data and lay down the tracks in the system network. It also prints error messages if needed.

PREAMBLE, a SIMSCRIPT module, defines the structures of the TSR program. It defines the entities, attributes, variables, and arrays that are common to all routines.

TAG.NODE tags every node that is not on a track as belonging to one of the following categories: within the north and south tracks, on the north or south track, on a track, or none of the above.

TRK.INPUT is called by MAIN to read user-defined input of the north track, south track, flight levels of the links that fall within these tracks, and those connected to these tracks. It also reads the disk number of the output disk file. The routine activates all the tracks between these two tracks, e.g., Tracks 7 through 17 of a 17-track system, with Tracks 1 through 6 forming the eastbound tracks and the remainder the westbound tracks.

TRK.NODE determines which nodes are the waypoints of the active track. An error message is printed for each waypoint that is not defined in the node network.

TRK.OUTPUT writes a binary file that gives the link number, track flag, and flight level code for each link with the given tracks active in the network.

TRK.OVERLAY sets the flight level code of each network link on the basis of its relationship with the active tracks. If no link connects two consequentive waypoints of a track, the link will be created. ADD.LINK is then called to add the created link to the network.

TRK.PLOT generates an output file that--when run with the TOPDRAWAR module in the computer system at the Center for Information Technologies (CIT) at Stanford University--will produce a graphical plot of the track system.

TRK.READ is called by the IN.PROC routine during program initiation. It reads in all the tracks of a track system for a single day. In the CEP region, the track system is invariant. In the NAT region, the eastbound tracks are in effect in the early part of the day, and the westbound tracks are active in the second part of the 24-hour period.

TRK.RESET resets all network conditions so that the program is ready to set the westbound tracks in the NAT region.

3.3 Meteorology Routine

3.3.1 Program Description

This routine prepares meteorological data for later computation in FTM and computes the headwind, crosswind, and temperature for each flight level of each link in the FPM.

The routine begins by reading in the network data. This is done by using the same input data files as the T[illegible]R. Next to be read are the rectangular regions (Meteorology Routine, Section I) where weather will be calculated. The routine determines all the blockettes in the rectangular regions and sets up the required data arrays. A blockette is a rectangular subregion of 10 degrees latitude by 10 degrees longitude. The weather prognosis data are transmitted by blockettes. The regions, called Quads, must be in the Northern Hemisphere. Only those data blocks whose blockettes are in the defined Quad will be read from the weather tape. The wind vectors in the weather data arrays are resolved into north-south and east-west components. At this point, the resultant weather data arrays are written into a data file for use by FTM.

Using these arrays, the routine proceeds to calculate for a given track setting the headwind, crosswind, and temperature at every flight level of each link in the network. For every link, the number of intermediate weather points is determined on the basis of the length of the link and the number of blockettes it traverses. The north and east wind components and the temperature at the four millibar-levels of these points and the two end nodes of the link are computed using the weighted average of the meteorology of the four weather-grid points closest to each. The wind components are then resolved along the link into headwind and crosswind components. The headwind, crosswind, and temperature of each flight level of the link are then computed using interpolation between millibar levels and trapezoidal integration of data along the link at a given flight level. These data are written onto a data file for use by FPM.

In a single run the routine can compute an entire day's weather for the east-bound and west-bound track setting in the NAT region.

3.3.2 Definition of Routines

BLOCKINDX determines the weather blockette for a point, given its latitude and longitude.

BLK.STRUCTURE determines the blockettes in each of the defined Quads. A Quad, or region on the globe where weather information is required, is composed of a whole number of blockettes. This routine also reserves the wind vector and temperature arrays.

BULLETIN decodes the bulletin number of the weather bulletin just read by the program. If this bulletin does not belong to the midlevel set, SEARCH is called. Data on the tape are written in the hexadecimal system.

GRIDNDX determines which weather Quad, if any, a given point falls within and the x-y coordinate indices of the weather grid data point immediately to the right of and below the given point.

GRID.OUTPUT writes the Quad data and flight level data for interpolation and transmission to the FPM and FTM.

HEADER decodes the blockette number, the bulletin number, and the forecast code of a blockette identifier.

IN.PROCESSOR reads in the system network from the input data file. The input is paced by keywords such as NODES, ALTITUDES, MILLIBAR LEVELS, LINKS, FLIGHT.LEVEL, and GO. Upon reading the keyword GO, all input data are successfully processed and stored.

LATNDX returns an integer number, given the latitude of one of the end nodes of a link. The difference between the two numbers for the two end nodes of the link helps to determine the number of intermediate weather points required.

LEG.WEATHER is called by MAIN to compute the headwind, crosswind, and temperature at each flight level over every link in the network.

MAIN controls the execution sequence of the individual routines to accomplish the purpose of the MET program.

MET.DATA reads and decodes the wind magnitude, wind direction, and temperature for a given number of atmospheric altitude levels after the data are determined to be relevant. It is called by TAPE.READ.

MET.INITIALIZATION, called by LEG.WEATHER, determines the the given network from a file generated by TSR and reserves the weather data arrays.

METLINK, called by LEG.WEATHER, determines the number of intermediate weather points and then computes the weather for the given link.

METLOAD, called by METREAD, transfers the data read by MET.DATA from the temporary storage location to the data arrays of each Quad.

MET.OUTPUT writes headwind, crosswind, and temperature at every flight level of each link into a binary file.

METREAD is called by TAPE.READ after the meteorological data of a blockette are read from the tape. It determines which Quads the blockette belongs to and calls MET.LOAD to transfer the data into the weather arrays of the Quads. A blockette can belong to more than one Quad because Quads can overlap.

MET.RESET resets a loop flag to allow the weather computation of a second track system in the same run. This feature is useful in the NAT weather computation.

METSUM is called by MET.LINK during the numerical integration of weather data over a given link.

PREAMBLE, a SIMSCRIPT module, defines the structure of the MET program. It defines the entities, attributes, variables, and arrays that are common to all routines. Data packings are specified in the module.

POST.PROC performs any remaining step to complete the initialization of the model before weather computation can proceed.

RHUMBHEADING, a function routine, calculates the rhumb line heading of a link, given the latitudes and longitudes of its end nodes. The direction of travel is from the from-node to the to-node of the link.

SEARCH is called by RATE.READ to skip over high-level and low-level weather prognosis data on the weather tape. In our model, only the mid-level data, i.e., 400-mb, 300-mb, 250-mb, and 200-mb levels are used.

TAPE.READ reads in the required weather data from the weather tape supplied by Suitland. It skips all spurious records and loads the blockettes in the defined Quads. After the tape is read, the routine performs error-check and data-averaging, if necessary.

WD.RESOLVE resolves all wind vectors given in terms of magnitude and direction (direction is given in meteorology convention) into north-south and east-west components. Positive values are assigned to south wind and west wind. The temperature and wind arrays are written into a data file for FTM.

3.4 Flight Planning Model

3.4.1 Program Description

Input Logic

A flowchart of the FPM input and external event logical segments is presented in Figure 4. At the beginning of a program operation, MAIN has control of program execution. The major function of MAIN is to control reading of the input data, processing of the data into the form required to perform the flight planning, and printing of the input data for user reference and verification.

The input data to FPM are grouped into 19 categories. Each category is preceded by a keyword that triggers the execution of the appropriate code segment that reads and processes the type of data in the category. These keywords are MISCELLANEOUS, FLIGHT.LEVEL, MILLIBAR LEVEL, NODE, ALTITUDE, LINK, TRACK, AIRPORT, ROUTE, RHUMBSECTOR, AIRCRAFT, OUTPUTVECTOR, TIME, SETLINK, SETROUTE, STRATEGY, PROCESSING ROUTENODES and FILE REWRITE. The data must be input in this order.

The kevword GO is inserted at the end of the input data. When this keyword is encountered, data management routines are called to process the data into the form required. Print routines are called depending on user options to print a version of the input data in a format to facilitate user reference and checking.

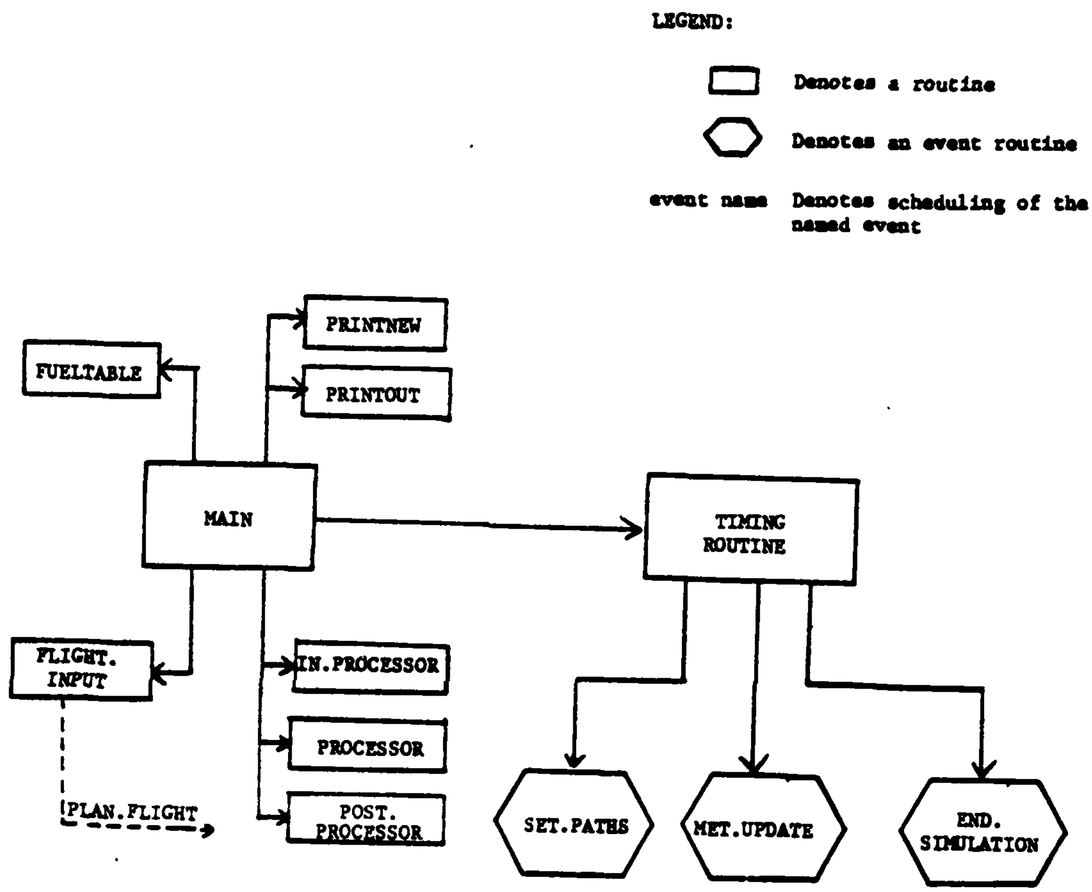


FIGURE 4 FLOW CHART OF FPM INPUT AND EXTERNAL EVENT PROCESSING LOGIC

MAIN then calls the FLIGHT.INPUT routine to read in the first flight from the input schedule. FLIGHT.INPUT schedules the first PLAN.FLIGHT event. The simulation is then started, and control of the program is passed to the TIMING ROUTINE, an internal SIMSCRIPT routine that controls simulation timing and event processing. The TIMING ROUTINE keeps track of all scheduled events and triggers the execution of events in proper time sequence. When an event occurs, the event routine with the same name as the event is executed. This event routine can call upon other routines as necessary.

External Event Processing Logic

The external events for the module are specified by the user at the end of the input data file. The time each event is to occur, as well as the parameters associated with each event, are read. The internal SIMSCRIPT TIMING ROUTINE schedules and executes each of these events at the specified time by exercising an event routine with the same name as the event.

A flowchart of the logical segments for processing these events is shown in Figure 4. The SET.PATHS event legalizes the specified link and route sets from the event time until the next SET.PATHS event. The weather data currently in core are headed by the first MET.UPDATE event and may be updated by subsequent events. END.SIMULATION should be the last event scheduled. Its event time is usually a large number. The execution of this event routine terminates the FPM and closes all the output files in an orderly manner.

The TIMING ROUTINE records all of these scheduled events and causes them to occur at the scheduled times.

Flight Planning Logic

The flowchart of the FPM flight planning logic is shown in Figure 5. The TIMING ROUTINE schedules the PLAN.FLIGHT event at the departure time of the flight. At the event time, the PLAN.FLIGHT event routine is executed. The routines DESCENT, DYNAM, ASCENT, GROUND DIST, FLT.PATH.PLOT and FLIGHT.INPUT are called sequentially in that order by the PLAN.FLIGHT event routine. Each of these routines may call other routines, only one of which is shown in Figure 5. These routines perform the flight planning, the printout of the flight plan, and further plotting of the flight path if required.

As in MAIN, FLIGHT.INPUT reads another flight from the flight schedule and schedules another PLAN.FLIGHT event. Since PLAN.FLIGHT events must be scheduled in chronological order, the input list of the flight schedule must be sorted with respect to the departure time.

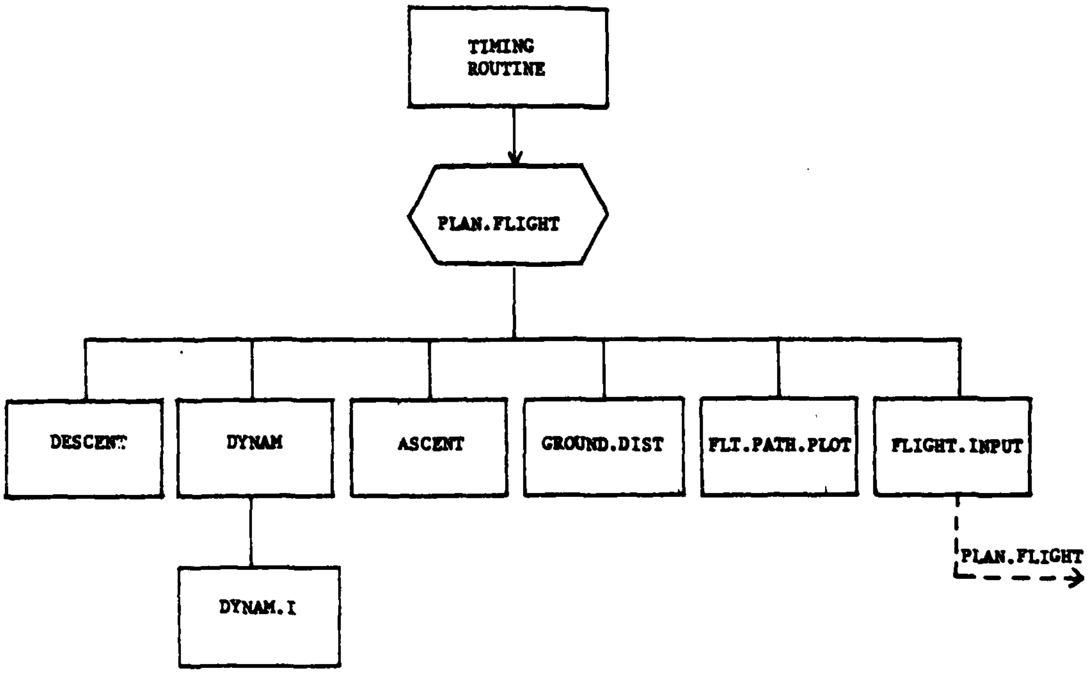


FIGURE 5 FLOWCHART OF FFM FLIGHT PLANNING LOGIC

3.4.2 Definition of Routines

ACR.DATA is called by IN.PROCESSOR during data input to read and store compactly the fuel data of each aircraft type.

ASCENT is called by the PLAN.FLIGHT event to determine the optimal climb profile after the backward dynamic programming is completed for a flight. It is a forward dynamic programming algorithm, and the origin airport is the starting node.

CLIMB is called by ASCENT to determine iteratively the takeoff weight of the flight, given its cruise weight at any node along a departing route. Climb time, climb distance, and climb fuel burn are used in the computation.

CONVERT, a function routine, converts a given coordinate in the DEG.MIN format into the decimal degree format.

CONV.LINKS, called by DESCENT, determines the descent profile when the descent distance from the cruise flight level of the aircraft is greater than the distance of the route node of one of the arrival routes to the airport. If the additional distance of the next link is still insufficient for a smooth descent, the aircraft is "popped down" arbitrarily at the beginning of descent.

DESCENT determines the descent profile of the flight. It initiates the state vectors of the dynamic programming algorithm at each of the descent nodes. It is called by the PLAN.FLIGHT event.

DIVERT.ROUTING determines the shortest route to a given airport from any node that is the first node of any arrival route to the airport. An array of these data is constructed for every airport in the network. This information is used only in the FTM to vector home any aircraft diverted from its flight plan by the traffic controller.

DIV.LINKS determines the ascent profile when the ascent distance to the cruise flight level of the aircraft is greater than the distance of the route node farthest from the origin airport. The route node is the last node of one of the departure routes from the airport. If the additional distance of the next link is still insufficient for a smooth ascent, the aircraft is "popped up" arbitrarily at the end of ascent.

DYNAM files all the state vectors created by DESCENT in the proper lists on the basis of flight cost. It calls DYNAM.INNER to perform the actual dynamic programming algorithm.

DYNAM.INNER is the key routine of FPM. It determines the flight costs of all optimal flight paths at every legal flight level from the airport node to the destination airport. It uses an algorithm that is driven by cost. The next state vector the algorithm proceeds from is always the one with the lowest flight cost. The search pattern is bound by the position of the next node and the heading of the next cruise link.

END.SIMULATION, an event routine, writes an FTM interface file. It should be the last event of the simulation.

FILE.READ reads the FTM interface file if it has been written by a previous run of the program. The vital information that must be recovered is the set of links that have been used in previous flight plans.

FILEWRITE is called by END.SIMULATION to write the FTM interface file. All relevant network information is transferred from the FPM to the FTM through this interface file.

FIRST.CR.NODE is called during the ascent phase of the algorithm to compare two profiles and choose the best one.

FLIGHT.INPUT reads in the flight data of a flight from the flight schedule. It checks for input errors and schedules the PLAN.FLIGHT at the schedule departure time.

FLT.PATH.PLOT is called by PLAN.FLIGHT (if required by the user) to generate an output data file of the flight path of the current flight. At the end of the FPM program step, the CIT TOPDRAWER graphic program is called to produce graphic plots of the flight profiles. Hence, this feature is computer-facility dependent.

FUELBURN determines the fuel burn and the transmit time of a given aircraft to traverse a given link at the given flight level and given clock time.

FUELTABLE generates a printout of the aircraft fuel data stored in the program. The printout is used for reference and verification.

GCDISTANCE determines the great-circle distance of a link in nautical miles, given the coordinates of its end nodes.

GROUND.DIST, called by PLAN.FLIGHT after an optimal flight path has been determined, determines the ground distance of the flight path.

IN.PROCESSOR is the primary input routine of the program. It reads in groups of data, each of which is preceded by the group keyword. The keyword will trigger logic transfer to the appropriate code segment to read and store the input data.

LAST.CR.NODE is called during descent to determine the optimal path from a node just before the top-of-descent to the destination airport.

LDFL.ENTRY is called by DIVERT.ROUTING to store given values in arrays.

LINKAGE determines the links that are connected to each of the nodes in the network. Airport from-routes and to-routes are also determined. The routes and links are members of currently active route and link sets.

MAIN controls the execution sequence of FPM. Input routines are executed, followed by printing routines if required. Control is then passed to the SIMSCRIPT TIMING ROUTINE to plan flights from the flight schedule.

MET.UPDATE, an event routine, allows the user to update the meteorology data of the links at the time of the event. Data are precalculated using the MET program.

NEXT.LEVEL.UP is called during the ascent phase to allow aircraft to climb to the next legal flight level at the first cruise node immediately following top-of-climb. This feature is necessary when one or more of the flight levels of the links entering the node are unavailable on the links leaving the node.

PATH.LISTING is called by the SET.PATHS event to write a file of the shortest path home from coastal landfalls to the airports. These data are used in FTM for domestic routing of diverted aircraft back to the destination airport.

PLAN.FLIGHT, an event routine, calls the DESCENT, DYNAM, and ASCENT routines to determine the optimal flight path. Upon successful completion of the backward sweep of the dynamic programming algorithm, it performs a forward sweep to recover the flight plan. It calls GROUND.DIST to determine the distance travelled and FLT.PATH.PLOT to produce a plot of the flight plan if requested. It reinitializes system parameters before calling FLIGHT.INPUT to read another flight off the flight schedule.

POST.PROCESSOR performs all remaining steps to prepare the program for flight planning. It normalizes the units of all data, reserves all yet-to-be-reserved data arrays, and calculates other remaining link-related parameters. It prints a message to indicate that the system is ready for simulation.

PREAMBLE, a SIMSCRIPT module, defines the structure of the FPM program. It determines how data are packed into quarter-word and half-word arrays. It also defines the entities, attributes, events, variables, and arrays that are common to all routines.

PRINTNEW prints the remainder of the input data and other program-generated data for reference and verification.

PRINTOUT prints some of the input of the program in an easy-to-read format for user reference and verification. Most of the data in this routine are read from input.

PROCESSOR performs some intermediate data preparations required by the program logic.

RHB.FILING is called by POST.PROCESSOR to determine the rhumb line heading of a great-circle flight path segment in the given sector of an origin-destination airport pair. The value of the heading is stored in a data array. This routine is called as many times as the number of sectors for each origin-destination pair given in the input fuel burn data.

RHUMBHEADING computes the rhumb line heading of a link, given the coordinates of its end nodes. The heading is measured from the geographic north to the line joining the from-node of the link to its to-node.

SET.PATHS, an event routine, reads in the link and route sets that will be legal from the event time of the present SET.PATHS to the event time of the next SET.PATHS. It calls LINKAGE and DIVERT.ROUTING to determine the links connected to each node and the airport routes and homing routes for diverted aircraft. PATH.LISTING is then called to write a file of homing routes.

TRK.READ is called by IN.PROCESSOR when triggered by the keyword TRACK to read the track file previously generated by TSR.

3.5 Flight Tracking Model

3.5.1 Program Logic

This program conducts the simulation of the flight plans determined by FPM. The input logic is quite similar to FPM, and many of the input items are FPM outputs. However, to conserve storage, only those oceanic links actually used by FPM, plus all domestic links and track links, used or not, are forwarded to FTM. Additional inputs describe strategy sequences, the boundary between 1,000 and 2,000-ft separation levels, and longitudinal and lateral separation data.

The simulation logic illustrated in Figure 6 is driven by the external event FLIGHT, which represents the acquisition of a flight plan by the system, sets up the AIRCRAFT data, and causes the scheduling of a subsequent TAKEOFF. TAKEOFF, in turn, determines the aircraft's time of arrival at the first cruise node and schedules the NODE.ARRIVAL routine. At the time of the node arrival, the CLR.AIRCRAFT routine is called to supervise the determination of: clearance range, the flight profile, whether or not there are any conflicts, and conflict resolution during later phases. CLR.AIRCRAFT determines step climbs. Then FLY.IT is called to determine the time of arrival at the next node, and NODE.ARRIVAL is rescheduled. When the last cruise node is reached, the call to CLR.AIRCRAFT is skipped, and the LANDING routine is scheduled. LANDING completes all processing of the flight and returns any storage it has used.

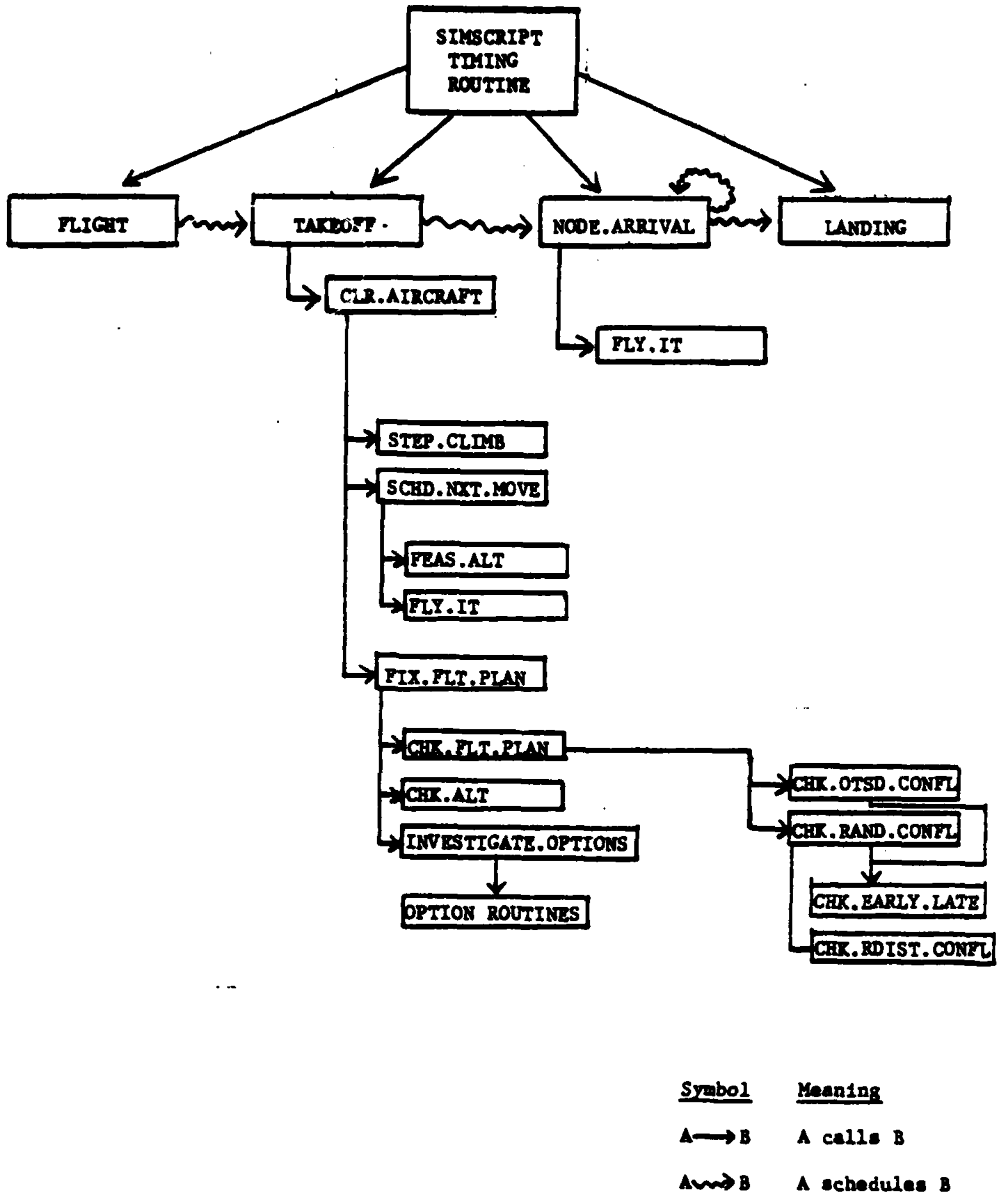


FIGURE 6 FLOW OF CONTROL AMONG MAJOR FPM ROUTINES

3.5.2 Definition of Routines

ACR.DATA is called by IN.PROCESSOR during data input to read and store compactly the fuel burn data of each aircraft type.

ADVANCE.AC determines the next clearance request node, if any, and the number of flight strips to be cleared at that node.

ALT.MATCH determines the entry of the flight level array that matches a given flight level over a given link.

ALT.SEP.LOGIC is called by CHK.ALT to apply vertical separation rules to a given potential conflict.

ALT.TEST checks for altitude conflicts between two given flight strips if they are filed at the same node.

CHK.ALT supervises the application of vertical separation rules.

CHK.DIST.CONFL checks for lateral conflicts between aircraft in links approaching or departing a common node.

CHK.EARLY.LATE checks for longitudinal separation conflicts at a node and supervises checks for lateral separation conflicts in links approaching or departing a node.

CHK.FLT.PLAN supervises the application of longitudinal and latitudinal conflict recognition routines.

CHK.NT.FIR is a function that finds the FIR number of the FIR about to be entered which is used to determine whether to apply tactical or strategic conflict avoidance.

CHK.OTS.CONFL supervises the check for conflicts between an OTS aircraft and other OTS aircraft or aircraft merging with or crossing the tracks. It is also used for domestic conflict checking.

CHK.RAND.CONFL supervises the check for conflicts between oceanic aircraft that are not approaching or leaving an OTS node.

CHK.RDIST.CONFL checks for lateral conflict between aircraft in links not having a common node.

CLIMB determines the ascent time, ascent distance, and ascent fuel during the ascent phase of a given aircraft. The distance from the top-of-ascent to the next node of the flight plan is also calculated.

CLR.AIRCRAFT supervises the entire clearance process including step climb.

CONVERT is a function that converts a given coordinate in the DEG.MIN format into the decimal degree format.

CR.CHK.STORAGE is used in post-input phase to create dummy aircraft entities and flight strips used for storing provisional flight plans constructed by conflict resolution routines.

CRUISE calculates the fuel burned for level flight over a given distance at a given altitude and Mach speed for a given aircraft.

DELAY is called from delay strategy routines to develop a schedule with a given amount of delay.

DIV.LINK determines the headwind, crosswind, and temperature of the flight levels between two nodes. It is called when an aircraft is diverted to a flight segment between two nodes for which no defined link exists. The first link of the link set is then used to connect the two nodes.

DIV.RTE.INPUT is called during input to read the diversion routes generated by FPM. These routes allow an aircraft that has been diverted to a landfall to be vectored back to the destination airport. This route will be the shortest route from the landfall to the airport.

DOM.CLIMB applies a climb conflict resolution strategy in the domestic environment.

DOM.DELAY applies a delay conflict resolution strategy in the domestic environment.

DOM.DESCEND applies a descend conflict resolution strategy in the domestic environment.

EW.RTN determines whether an aircraft is flying toward the east or the west when it leaves the current node. The current node may be the origin airport, the destination airport, or any waypoint node of the network.

FEAS.ALT determines whether an aircraft can climb to and cruise at a given altitude with its current aircraft weight.

FIR.BITSET is called by FIR.INPUT to set the corresponding bit in the ND.FIR word of every node between and including the two given nodes. The setting of the bit tags these nodes as belonging to the given Flight Information Region (FIR).

FIR.INPUT is triggered by the keyword FIR REGION in the input list to read in all FIRs and their nodes. At the end of the input, any node that does not have its ND.FIR word set is considered domestic and has its word set accordingly.

FIR.MMT tallies the aircraft counts in each of the defined FIRs. When an aircraft crosses from one FIR to another, the aircraft count of the first is decreased by one and that of the other increased by one.

FIX.FLT.PLAN supervises conflict detection and resolution. The simulation log (CNSO file) records Type 1, Subtypes 1 and 2, and Type 2, Subtype 1.

FLIGHT, an event routine, reads the flight plan of the flight and schedules a TAKEOFF event. It checks for input errors and creates all required flight strips associated with the flight.

FLY.IT determines the aircraft weight and arrival time at the next node of the flight plan after the aircraft has been cleared.

FUELBURN determines the fuel burn and the transit time of the transit between two consequent nodes on the flight plan. The logic covers the ascent, cruise, and descent phases of the flight.

FUELTABLE generates a printout of the aircraft fuel data stored in the program. The printout is useful for reference and verification.

GO.DOWN determines a legal flight level that is a given number of legal levels below the current flight level and is in the same direction as the current level.

GO.UP determines a legal flight level that is a given number of legal levels above the current flight level and is in the same direction as the current level.

GRIDNDX determines which weather array, if any, a given point belongs to and the x-y coordinate indices of the weather grid point that is immediately to the right of and below the given point.

HDGDIFF determines the heading difference between the headings of two aircraft flying over two different links.

HOME.ROUTE finds a landfall for the rerouted oceanic aircraft such that the distance from the exit oceanic node to the destination airport is the minimum. The logic makes use of an array produced by the SET.PATH event in the preceding FPM.

IN.PROCESSOR is the primary input routine of the program. It reads in groups of data, each of which is preceded by the keyword of the group. The keyword triggers logic transfer to the appropriate code segment to read and store the input data.

INTERFACE reads the interface file created by a previous FPM. The file contains all the relevant network data pertaining to a particular aircraft separation standard scenario.

INVESTIGATE.OPTIONS, an intermediate level routine between FIX.FLT.PLAN and strategy routines, applies the latter in a sequence indicated by the STRAT matrix.

LANDING, an event routine, is executed when an aircraft lands at its destination airport. It computes the actual flight fuel burn and travel time of the flight. It also performs the necessary house-cleaning chores before the aircraft entity is destroyed.

LATNDX returns an integer number, given the latitude of one of the end nodes of a link. The difference of the two numbers for the two end nodes of the link helps to determine the number of intermediate weather points required.

LEGAL.ALT determines whether the flight level at which an aircraft intends to fly is a legal flight level over the departure link of the aircraft.

LINKAGE determines the from-routes and to-routes of every airport. Only currently active routes are included.

LO.HEMIS.ALT determines the next lower flight level in the same direction for an aircraft flying over a link at a particular flight level.

MAIN controls the execution sequence of FTM. Input routines are executed first and followed by printing routines if requested. Control is then passed to the SIMSCRIPT TIMING ROUTINE, which executes both internal and external events scheduled in the sequence of their event times.

MAKE.MR.LIST uses CHK.FLT.PLAN to create a list of aircraft that are "Mach related" to a given aircraft, i.e., they entered oceanic air-space at the same place as the aircraft and followed the same course thereafter.

METLEVEL is called to determine the interpolation factors for two atmospheric pressure levels that are closed to each of the given global flight levels.

METLINK computes the headwind, crosswind, and temperature at each of the legal flight levels over a given link. It determines the number of intermediate weather points of the link and then performs a trape-zoidal integration of the weather data over the link.

MET.STRUCTURE is called by IN.PROCESSOR to input the infrastructure of the weather model. These data are produced earlier by the MET pro-gram.

METSUM is called by METLINK during the numerical integration of weather data over a given link.

MET.UPDATE calculates the weather conditions of all links in the network at the time the event is triggered. This allows the user to update the weather conditions as appropriate.

MOVE.AC.DATA is a service routine that transfers flight plans and related information from one CK.AC to another.

NODE.ARRIVAL, an event routine, is executed when an aircraft arrives at a node. The CLR.AIRCRAFT routine is called for clearance to the next node. If the next node is the destination airport, a LANDING event is scheduled. Otherwise another NODE.ARRIVAL event is scheduled at the next node. The event time is determined by calling FLY.IT.

OCN.ALTER.TRACK applies a track change conflict resolution strategy to an OTS aircraft whose requested track and flight level are in conflict with another aircraft.

OCN.CH.MACH changes Mach speed for oceanic aircraft in an attempt to resolve conflicts.

OCN.CLIMB applies a climb conflict resolution strategy to an aircraft being cleared or recleared for oceanic airspace.

OCN.DELAY applies a delay conflict resolution strategy to an aircraft being cleared or recleared for oceanic airspace.

OCN.DESCE applies a descend conflict resolution strategy to an aircraft being cleared or recleared for oceanic airspace.

OCN.RNDM.REROUTE is an unused and not completely tested routine for resolving conflicts of a non-OTS aircraft with OTS or non-OTS aircraft by changing course.

OCR.BITSET is called by OCR.INPUT to set the corresponding bit in the ND.OCR.CTL.RGN word of every node between and including the two given nodes. The setting of the bit tags these nodes to indicate their oceanic control regions.

OCR.INPUT is executed when IN.PROCESSOR encounters the keywords OCEAN CONTROL REGION in the input list. It reads in the ocean control regions and the nodes that belong to each region.

POST.PROCESSOR performs all the remaining steps to ready the program for flight tracking. Typically these functions do not fall into any clearly definable category.

PREAMBLE, a SIMSCRIPT module, defines the structure of the FTM program. It defines the quarter-word and half-word packing of arrays. It also defines the entities, attributes, events, variables, and arrays that are common to all routines.

PRINT.AC lists aircraft status in the debugging log.

PRINTNEW prints part of the input data and other program generated arrays for reference and verification.

PRINTOUT prints some of the input data read directly from the input list in an easy-to-read format for network reference and verification.

RD.STRAT reads strategy inputs and develops the STRAT matrix, which is used to control the application of the strategy routine to conflict resolution.

READ.ND.ATTRIB provides the capability to input two different node attributes. Depending on input parameters, it either reads the strategy code or the clearance request/delivery code of the node group and the nodes in the group.

RHUMBHEADING computes the rhumb line heading of a link, given the coordinates of its end nodes. The heading is measured from the geographic north to the line joining the from-node to the to-node of the link.

SCHD.NXT.MOVE determines the number of nodes ahead of the current node for the next clearance, i.e., the range of the next clearance. The routine also defines departure altitudes for each node, including the current node, in the range.

SET.PATHS, an event routine, reads in the link and route sets that will be legal from the event time of the present SET.PATHS to the event time of the next SET.PATHS. It calls LINKAGE to determine the airport routes and DIV.RTE.INPUT to read the airport homing routes generated by an equivalent SET.PATHS in the preceding FPM.

SET.TRACE, an external event routine, sets the global variable TRACE.FLAG at an input value. TRACE.FLAG controls the amount of output dumped into the debug log.

STEP.CLIMB determines whether a step climb at the current oceanic node is feasible, legal, and conflict-free. If so, it assigns the new altitude.

TAKEOFF, an event routine, is scheduled after a flight is read by the FLIGHT event routine. It inserts an aircraft at the origin airport and initiates a request for clearance. If cleared, a NODE.ARRIVAL event is scheduled at the time the aircraft reaches the next node on the flight plan.

WHICH.TRACK determines whether an aircraft approaching the ocean is to travel in the OTS and, if so, which track number it plans to traverse.

3.6 Report Generating Package

3.6.1 Program Logic

There are 11 submodules in this report package. The modules read the consolidated simulation output file, sort it, extract the data appropriate to each module, and print the statistics in tabular formats. It also produces a list of diagnostic messages at the beginning of the report.

3.6.2 Definition of Programs

FTM1A determines the regression coefficients for estimating actual time and fuel cost of uncleared flights, if any, from the planned values. These coefficients are derived from analysis of conflicting flights in the model. It prints 19 tables of the daily cost results. The tables are self-explanatory. The flow groups in the tables are defined by the user.

FTM2 determines the difference between the daily aggregate differences between the flight time and fuel burn of the daily traffic. The data is further divided into OTS and non-OTS traffic.

FTM3 determines the hourly instantaneous aircraft counts (IACs) for each of the defined FIRs in the model. The maximum and minimum IAC are given, along with the number of aircraft entering and leaving each FIR.

FTM4 determines the statistics of oceanic step-climb requests and clearances for the OTS and non-OTS flights in the model.

FTM5 determines the appropriate statistics of the number of flight levels requested versus those cleared as requested at oceanic entry nodes and oceanic exit nodes. The statistics are determined for OTS, non-OTS, and all traffic--including the traffic in each of the defined flow groups.

FTM6 determines the distribution of the fuel burn and flight time by altitude diversion during oceanic transit of all flights in the simulation day. The statistics for the total number of flights as well as flights in each of the defined flow groups are tabulated.

FTM7 determines the percent distribution of flight at the various flight levels by the tracks in the OTS. The statistics are computed for aircraft in both the eastbound and the westbound flows at oceanic entry as well as oceanic exit.

FTM8 determines the percent distribution of diverted aircraft by altitude as well as lateral diversion. The statistics are given at ocean entry and exit for each of the defined aircraft flow groups.

FTM9 determines the planned speeds and altitudes of all cleared flights. These statistics are broken down in classes of OTS and non-OTS, each of which is again classified into eastbound and westbound flows for each of the flow groups defined by the user.

FTM10 compiles the statistics of longitudinal separation between aircraft by hour in the 24-hr simulation period.

FTM11 computes the number of costed and noncosted flights by aircraft type as well as by flow group.

4.0 OUTPUT OF FCM RESULTS

Most of the outputs of the individual FCM modules are disk data files for subsequent modules. The systemic nomenclature is described in the next subsection.

4.1 Nomenclature

The output files are named in the standard format (system code.user code.family code.member code.scenario code),

where:

- o System code is the code of the computer system; in the present case it is WYL.
- o User code is the code of the user, e.g., XG.A68.
- o Family code is the code of the region to which the model is applied, e.g., NAT1 for North Atlantic.
- o Member code is the name of the file being written, e.g., NODES.
- o Scenario code is the separation standard and year code if year-dependent, e.g., N60, which demands that nodes are 60 n.m. apart.

Therefore, a perfectly legal name is WYL.XG.A68.NAT1.NODES.M60.

The relationships between the separation modules of the FCM may be determined by reading the names of the input and output files.

4.2 Module Printout

4.2.1 FPM Flight Plan

If so instructed, the FPM module produces a printout of the flight plan of each flight planned. A sample flight plan is given in Table 1.

In the printout, the first eight lines give a running report of the program start-up. The flight plan itself begins at the ninth line. The flight number, the origin and destination airports, and the estimated time of departure and arrival are given as well as the flight time, flight fuel consumption, and the dollar cost of the flight. The cost figures are those of a given base year.

Table 1 Sample Flight Plan

```
UNRECOGNIZABLE WUKU MILL ON INPUT CARD!
INPUT PROCESSING COMPLETE!
SYSTEM READY FOR SIMULATION!
FLT WN 8     OF TYPE 74ST IS SCHEDULED AT    31.08 HR!
PREPROCESSED WEATHER DATA ARE READ FROM DISK AND LOADED.
TIME OFFSET OF THIS RUN IS      33.00
WEATHER IS READ FROM UNIT       1.
  ***MIN FUEL OBJECTIVE FUNCTION***
```

FLT	NO	ORG	DEST	ETD	ETA	TIME	FUEL	COST	T.O.WT	LAND.WT
WNA	8	SEA	LGW	3105	3947	10.53	346249	24594	839249	493000

ND	LK	NXND	GND	HDG	RHB	ALT	WT	LVLTM	TW	XW	TEMP
479	3050	578	2081	92	71	290	839249	4.84	20	7	-43
578	3221	582	262	87	89	290	677414	.81	65	6	-46
582	3222	540	188	91	89	290	661169	.34	62	4	-46
540	3018	266	418	91	89	330	649000	.75	67	11	-51
266	1737	202	417	82	108	290	624901	.75	55	10	-41
202	1214	140	409	90	108	330	599333	1.64	42	29	-46
140	728	76	457	113	126	330	576130	.89	30	42	-45
76	2549	380	305	96	126	370	549620	2.05	34	11	-53
380	3155	696	202	100	126	370	533786	1.46	27	21	-54
696	3581	683	351	31	143	370	523379	1.06	-31	46	-54
683	3568	651	108	35	143	370	504609	.28	2	61	-52
651	3569	500	123	38	143	370	498934	.06	2	73	-52

```
PORT DEP RTE  751    FX DEP RTE     0    PORT ARR RTE 1453    FX ARR RTE  349

GROUND DISTANCE(INCLUDING TERMINAL MANEUVER) COVERED        5357  NM
```

The next group of lines gives the flight particulars of interest by flight segment. The node and link numbers are internal program codes given to the entities. Ground distance of each link is given in nautical miles. Tailwind and crosswind are given in knots, and temperature in degrees Celsius.

The ground distance of the total flight is given and is usually greater than the sum of the individual links given in the flight plan. This is because the distances covered during ascent, descent, and maneuver are not given in the flight plan.

4.2.2 FTM Simulation Log

During the execution of each FTM, a simulation log is produced. The level of detail in the log is determined through user-defined inputs. An example of portions of a simulation log is provided in Table 2. Information on the progress of each aircraft through the modeled system is printed. Columns 1 to 3 of each line contain a selection code of the type of printout produced. Columns 4 though 19 contain the flight identification code. The rest of the line describes the occurrence of control action.

The simulation log can be very useful for program debugging and for detailed tracking of aircraft through the modeled system. This output is optional and may be turned on and off at will during the simulation by use of the SET.TRACE event.

4.2.3 Simulation Reports

A sample output of a single table out of a simulation report is given in Table 3. There are altogether 11 report submodules that give a variety of statistics.

In the sample table given, the cost figures of the aircraft in each of the user-defined flow groups are given.

Table 2 Sample Simulation Log Output

```
2FDMID  44   3246   547 3179  40N/ 59W   330     330   3224   534  620.0  .84    0     0     0     0  0
2FDMID  44   3246   550 3001  49N/ 55W   340     330   3246   540  610.3  .84    0     0     0     0  2
2FDMID  44   3246   270 1769  50N/ 50W   340     340   3307   547  601.2  .84    0     0   633     4  0
2CHMID  44   3246      PTL CFL WITH  AALT DALT  AT OR NEAR  TYPE   TIME DIFF  NODE
2CDMID  44   3246         EAST 86      340 340   53N/ 50W     1        -14    270
2FDMID  44   3246   206 1266  51N/ 40W   350     340   3350   562  583.7  .84    0     0   531     4  0
2CHMID  44   3246      PTL CFL WITH  AALT DALT  AT OR NEAR  TYPE   TIME DIFF  NODE
2CDMID  44   3246         EAST 86      340 340   51N/ 40W     1        -15    206
2FDMID  44   3246   146  796  53N/ 30W   360     340   3431   561  566.8  .84    0     0   432     4  0
2CHMID  44   3246      PTL CFL WITH  AALT DALT  AT OR NEAR  TYPE   TIME DIFF  NODE
2CDMID  44   3246         EAST 86      340 340   53N/ 30W     1        -15    146
2FDMID  44   3246    85  553  53N/ 20W   370     340   3510   545  551.5  .84    0     0   324     4  0
2CHMID  44   3246      PTL CFL WITH  AALT DALT  AT OR NEAR  TYPE   TIME DIFF  NODE
2CDMID  44   3246         EAST 86      340 340   53N/ 20W     1        -15    85
2FDMID  44   3246    60 3134  53N/ 15W   370     340   3530   545  543.7  .84    0     0   217     5  0
2CHMID  44   3246      PTL CFL WITH  AALT DALT  AT OR NEAR  TYPE   TIME DIFF  NODE
2CDMID  44   3246         EAST 86      340 340   53N/ 15W     1        -15    60
2FDMID  44   3246   693 3551  53N/  9W   370       0      0     0   0.  0.      0     0     0     0  2
2FDMID  44   3246   706 3552  51N/  1W   370       0      0     0   0.  0.      0     0     0     0  0
2FDMID  44   3246   661 4430  51N/ -3W   370       0      0     0   0.  0.      0     0     0     0  0
2FDMID  44   3246   495    0  50N/ -9W     0       0      0     0   0.  0.      0     0     0     0  0
2MHMID  44   3246         MACH RELATED AC      ALT
2MDMID  44   3246             AF   1327          -1
2MDMID  44   3246             DF   329           -1
2MDMID  44   3246             EAST 97            -1
2MDMID  44   3246             EAST 86            -1
I IDLYFS   1 NODES ARE 550 474
I OCN.DELAY PROBABLY CANNOT MACH SEP..DATA IS    .239    .033    .333
XT MID  44   3246    270 501 ODLY
CTAMID  44   3246 DEN FRA B747  550 49N/ 55W 330   60 53N/ 15W 340 340 EAST 86   501 ODLY   60
CTOMID  44   3246  550 49N/ 55W   4  270 50N/ 50W  .84  3 340  .84  3 340   60   0 -1  DEN FRA B747  5  501
KT EAST 74   3247 ---AR--- EAST 74   AT 32.7765 WEIGHT 581091 AT 53N/ 20W NODE   85 FL 320 --------
CT4EAST 74   3247 ATTEMPTING STEP CLIMB  AT NODE   85, 53N/ 20W
CT5EAST 74   3247 STEP CLIMB FROM FL 320 TO FL 330 AT   85, 53N/ 20W
KT MID  69   3247 ---AR--- MID  69   AT 32.7808 WEIGHT 629661 AT 55N/ 40W NODE  210 FL 310 --------
CT4MID  69   3247 ATTEMPTING STEP CLIMB  AT NODE  210, 55N/ 40W
CT5MID  69   3247 STEP CLIMB FROM FL 310 TO FL 340 AT  210, 55N/ 40W
LT UCAR 92   3247 ---LA--- UCAR 92   AT 32.7812 WEIGHT 331973 AT-35N/ 59W NODE  434 FL 310 --------
KS UCAR 92   3247 2300 2607 13.53  9.53  191   2315 3247 13.54  9.53  191
KT VM   013  3247 ---AR--- VM   013  AT 32.7824 WEIGHT 525614 AT 18N/ 55W NODE  387 FL 360 --------
LT UCAR 178  3247 ---LA--- UCAR 178  AT 32.7832 WEIGHT 505671 AT 41N/ 74W NODE  461 FL 380 --------
KS UCAR 178  3247 2300 2504 29.27  9.53  339   2315 3247 29.30  9.53  339
KT EAST 69   3247 ---AR--- EAST 69   AT 32.7835 WEIGHT 581848 AT 53N/ 20W NODE   85 FL 350 --------
KT SIBE 29   3247 ---AR--- SIBE 29   AT 32.7837 WEIGHT 224162 AT 28N/ 71W NODE  738 FL 380 --------
CTASIBE 29   3247 MAD HAV B707  738 28N/ 71W 380  743 26N/ 76W 380 380          0         0
CTOSIBE 29   3247  738 28N/ 71W  64  738 28N/ 71W  .79  0 380  .79  0 380    0    0  1  MAD HAV B707  2    0
KT EAST 89   3247 ---AR--- EAST 89   AT 32.7842 WEIGHT 569312 AT 54N/ 15W NODE   61 FL 340 --------
XT EAST 89   3247     693   3 DDES
CTAEAST 89   3247 YMX LHR 74ST   61 54N/ 15W 340  693 53N/  9W 350 350 MID  36      3 DDES    0
KT AF   1327 3247 ---AR--- AF   1327 AT 32.7844 WEIGHT 644389 AT 51N/ 40W NODE  206 FL 320 --------
CT4AF   1327 3247 ATTEMPTING STEP CLIMB  AT NODE  206, 51N/ 40W
CT5AF   1327 3247 STEP CLIMB FROM FL 320 TO FL 330 AT  206, 51N/ 40W
LT TW   0840 3247 ---LA--- TW   0840 AT 32.7881 WEIGHT 517335 AT 42N/-12W NODE  494 FL 370 --------
KS TW   0840 3247 2512 3300 13.55  7.35  191   2527 3247 13.53  7.34  190
KT EAST 66   3247 ---AR--- EAST 66   AT 32.7884 WEIGHT 511854 AT 54N/ -1W NODE  632 FL 370 --------
```

Table 2 (Continued)

```
KT EAST 73    3248 ---AR--- EAST 73   AT 32.7932 WEIGHT 517508 AT 50N/  6W NODE  670 FL 370 --------
CTAEAST 73    3248 EWR CDG B747  670 50N/  6W 370  668 50N/  4W 370 370              0          0
LT UCAR 90    3248 ---LA--- UCAR 90   AT 32.7971 WEIGHT 506444 AT-35N/ 59W NODE  434 FL 310 --------
KS UCAR 90    3248 2300 2504 23.12  9.55  325   2315 3248 23.07  9.55  325
KT ECS  25    3248 ---AR--- ECS  25   AT 32.7980 WEIGHT 510496 AT 52N/  5W NODE  698 FL 370 --------
KT UIBE 18    3248 ---AR--- UIBE 18   AT 32.8001 WEIGHT 544171 AT 48N/  8W NODE   26 FL 340 --------
!  UIBE 18    3248 AC UIBE 18   ARRIVED IN TYPE 1 CONFLICT
!  UIBE 18    3248 AC UIBE 18   ARRIVED IN TYPE 1 CONFLICT
!  UIBE 18    3248 AC UIBE 18   ARRIVED IN TYPE 1 CONFLICT
!  UIBE 18    3248 AC UIBE 18   ARRIVED IN TYPE 1 CONFLICT
CTAUIBE 18    3248 ATL LIS 74ST   26 48N/  8W 340  683 48N/  4W 370 370 ECS  30   999 DXXX    0
KT UIBE 19    3248 ---AR--- UIBE 19   AT 32.8045 WEIGHT 523534 AT 43N/  8W NODE  696 FL 360 --------
KT WEST 60    3249 ---AR--- WEST 60   AT 32.8102 WEIGHT 600122 AT 70N/ 60W NODE  341 FL 290 --------
KT UIBE 21    3249 ---AR--- UIBE 21   AT 32.8104 WEIGHT 557649 AT 49N/ 20W NODE   81 FL 340 --------
CT4UIBE 21    3249 ATTEMPTING STEP CLIMB  AT NODE   81, 49N/ 20W
CTSUIBE 21    3249 STEP CLIMB FROM FL 340 TO FL 360 AT   81, 49N/ 20W
KT SU   0342 3249 ---AR--- SU   0342 AT 32.8105 WEIGHT 232447 AT 60N/ -5W NODE  758 FL 370 --------
KT EAST 76    3249 ---AR--- EAST 76   AT 32.8124 WEIGHT 588675 AT 50N/  6W NODE  670 FL 350 --------
CTAEAST 76    3249 JFK FCD 74ST  670 50N/  6W 350  668 50N/  4W 350 350              0          0
KT DF   329   3249 ---AR--- DF   329  AT 32.8172 WEIGHT 387356 AT 51N/ 40W NODE  206 FL 350 --------
KT EAST 68    3249 ---AR--- EAST 68   AT 32.8195 WEIGHT 508667 AT 54N/ -1W NODE  632 FL 370 --------
KT EAST 79    3249 ---AR--- EAST 79   AT 32.8233 WEIGHT 550033 AT 53N/ 15W NODE   60 FL 360 --------
CTAEAST 79    3249 YMX FRA 74ST   60 53N/ 15W 360  693 53N/  9W 370 370 EI   7108 999 DXXX    0
KT SCAN 24    3250 ---AR--- SCAN 24   AT 32.8290 WEIGHT 624463 AT 65N/ 60W NODE  336 FL 290 --------
LT KL   777   3250 ---LA--- KL   777  AT 32.8326 WEIGHT 507698 AT 11N/ 67W NODE  432 FL 360 --------
KS KL   777   3250 2521 3308 19.97  7.23  186   2536 3250 20.11  7.23  187
KT SIBE 20    3250 ---AR--- SIBE 20   AT 32.8395 WEIGHT 574127 AT 26N/ 30W NODE  119 FL 330 --------
 T SIBE 20    3250 OCEANIC CLEARANCE CONFLICT WITH SIBE 7
2ANSIBE 20    3250   FLIGHT   ORG DST ACR  MACH  TRACK  NODE  POSITION  NR.TO.GO  NR.TO.CLR  EW
2ADSIBE 20    3250 SIBE 20    CCS LIS 74ST  .84     0    119  26N/ 30W      3          1    .   -1
2FHSIBE 20    3250     ND    LK  POSITION  PLN.A  DEP.A   ETA  SPEED  WGT   MCH  DAMT DTYP GDNO RGNO RQDL TRK
2FDSIBE 20    3250    432 5140  11N/ 67W   290    290   2815   513  740.4  .84    0    0    0    0 0
2FDSIBE 20    3250    387 2619  18N/ 55W   290    290   3001   509  666.6  .84    0    0    1   33 2
2FDSIBE 20    3250    239 1512  19N/ 50W   330    310   3035   524  646.6  .84    0    0  602   32 0
2FDSIBE 20    3250    177 1023  22N/ 40W   330    330   3143   531  609.0  .84    0    0  502    1 0
2FDSIBE 20    3250    119  577  26N/ 30W   350    350   3250   521  574.1  .84    0    0  405    8 0
2CHSIBE 20    3250       PTL CFL WITH  AALT DALT  AT OR NEAR  TYPE   TIME DIFF  NODE
2CDSIBE 20    3250          SIBE 7       350 350   26N/ 30W    1           5    119
2FDSIBE 20    3250     63 2504  31N/ 20W   370    350   3400   521  540.7  .84    0    0  302    8 0
2CHSIBE 20    3250       PTL CFL WITH  AALT DALT  AT OR NEAR  TYPE   TIME DIFF  NODE
2CDSIBE 20    3250          SIBE 7       350 350   26N/ 30W    5                119
2FDSIBE 20    3250    374 4718  33N/ 16W   370      0      0     0   0.  0.     0    0    0    1 2
2FDSIBE 20    3250    502    0  39N/  9W     0      0      0     0   0.  0.     0    0    0    0 0
XT SIBE 20    3250     119 310 ODES
CTASIBE 20    3250 CCS LIS 74ST  119 26N/ 30W 330   63 31N/ 20W 350 330 SIBE 7    310 ODES    0
CTOSIBE 20    3250  119 26N/ 30W   8  119 26N/ 30W  .84  0 350  .84  0 330    0   0 -1  CCS LIS 74ST  1  310
KT +TV  868   3251 ---AR--- +TV  868  AT 32.8451 WEIGHT 510301 AT 51N/ -3W NODE  661 FL 370 --------
KT PA   0202 3251 ---AR--- PA   0202 AT 32.8516 WEIGHT 536944 AT 30N/ 69W NODE  731 FL 360 --------
CTAPA   0202 3251 GIG JFK B747  731 30N/ 69W 360  402 38N/ 72W 380 380              0          0
CTOPA   0202 3251  731 30N/ 69W  16  731 30N/ 69W  .84  0 380  .84  0 380    0   0  1  GIG JFK B747  4     0
KT OO   1702 3251 ---AR--- OO   1702 AT 32.8538 WEIGHT 337750 AT 51N/  2W NODE  655 FL 370 --------
CTAOO   1702 3251 PTP BRU L10   655 51N/  2W 370  630 51N/ -1W 390 390              0          0
LT WEST 58    3251 ---LA--- WEST 58   AT 32.8369 WEIGHT 500946 AT 51N/  0W NODE  501 FL 370 --------
KS WEST 58    3251 2308 3308 18.68  9.54  263   2315 3251 18.82  9.61  265
KT EAST 93    3252 ---AR--- EAST 93   AT 32.8657 WEIGHT 554939 AT 54N/ 10W NODE  640 FL 350 --------
```

Table 3 Sample Simulation Report

FAMILY NAT1 MONTH JUL YEAR CODE Y1 SCENARIO S6C/V2/T15 RERUN 2

DAILY OCD SUMMARY --

TOTAL ACTUAL COST BREAKDOWN FOR ALL COSTED CLEARED TRAFFIC, BASED ON FTM ESTIMATE FOR UNCLEAREDS

ORIGIN AND DESTINATION CLASS	NUMBER OF FLIGHTS			FUEL COST ($000)			CREW COST ($000)			MAINTENANCE COST ($000)			TOTAL COST ($000)		
	EB	WB	TOT	EB	WB	TOT	EB	WB	TOT	EB	WB	TOT	EB	WB	TOT
SCANDINAVIA-NORTH AMERICA	15	15	30	169	198	367	56	58	114	46	52	98	271	308	579
EUROPE-EASTERN NORTH AMERICA	122	130	252	1437	1894	3331	430	516	945	392	475	867	2259	2885	5143
EUROPE-MID NORTH AMERICA	36	37	73	414	550	963	133	152	286	126	137	263	673	839	1512
EUROPE-WESTERN NORTH AMERICA	19	14	33	386	281	667	108	81	189	86	62	148	580	424	1004
EUROPE-CARIBBEAN	12	13	25	175	195	369	49	52	101	47	52	99	271	299	569
IBERIA-USA	14	13	27	150	167	317	47	46	93	48	45	93	245	258	503
IBERIA-CANADA	3	3	6	27	39	65	9	10	19	9	10	19	45	59	103
IBERIA-CARIBBEAN	9	9	18	125	117	242	37	33	71	32	29	61	194	179	374
NORTH AMERICA-AFRICA	2	2	4	28	39	67	10	11	20	4	5	9	42	55	96
EUROPE-ICELAND	9	8	17	27	25	52	10	9	19	6	6	11	43	40	82
EUROPE-AZORES	5	10	15	11	30	41	3	8	12	3	8	11	17	46	64
US/CANADA-CARIBBEAN/S. AMER	74	81	155	300	394	694	102	121	223	106	125	232	508	640	1149
MIDEAST/AFRICA-CARIB/S AMER	1	0	1	9	0	9	3	0	3	4	0	4	16	0	16
GREENLAND-USA/CANADA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ALL	321	335	656	3257	3928	7185	997	1098	2094	910	1005	1914	5164	6031	11193

APPENDIX A

CONFLICT RESOLUTION STRATEGIES
FOR
OTS AND RANDOM TRAFFIC, EASTBOUND
AND WESTBOUND, AIRCRAFT IN FLIGHT AND
AT COASTAL AIRPORTS

GANDER ACC EASTBOUND OTS CONFLICT RESOLUTION STRATEGIES FOR 120-60 NMI LATERAL/2000 FT VERTICAL COMPOSITE MINIMA (BASELINE SYSTEM) FOR AIRCRAFT IN FLIGHT

1. Climb 2000
2. Descend 2000
3. -M.01
4. Climb 4000
5. Divert 60 nmi (Adj. comp.) + 1000
6. Divert 60 nmi (Adj. comp.) - 1000
7. Climb 2000 & -M.01
8. Descend 2000 & -M.01
9. Divert 60 nmi (Adj. comp.) + 3000
10. Lose up to 2 min. (by ocean entry point)
11. Divert 60 nmi (Adj. comp.) + 1000 & -M.01
12. Divert 60 nmi (Adj. comp.) - 1000 & -M.01
13. Divert 120 nmi (Adj. std.)
14. Divert 120 nmi (Adj. std.) & climb 2000
15. Divert 120 nmi (Adj. std.) & descend 2000
16. Divert 120 nmi (Adj. std.) & -M.01
17. Divert 120 nmi (Adj. std.) & climb 4000
18. Divert 120 nmi (Adj. std.) & climb 2000 & -M.01
19. Divert 60 nmi (Adj. comp.) + 3000 & -M.01
20. Divert 120 nmi (Adj. std.) & descend 2000 & -M.01
21. Climb 2000 & lose 2 min.
22. Descend 2000 & lose 2 min.
23. Lose 2 min. & -M.01
24. Climb 2000 & lose 2 min. & -M.01
25. Descend 2000 & lose 2 min. & -M.01
26. Climb 4000 & -M.01
27. Divert 60 nmi (Adj. comp.) - 3000
28. Descend 4000
29. Climb 4000 & lose 2 min.
30. Climb 4000 & lose 2 min. & -M.01
31. +M.01
32. Hold 6 min.

(Continued)

(2)

33. Descend 6000
34. Divert 180 nmi (2nd comp.) + 1000
35. Divert 180 nmi (2nd comp.) - 1000
36. Divert 180 nmi (2nd comp.) + 3000
37. Divert 240 nmi (2nd std.)
38. Divert 240 nmi (2nd std.) + 2000
39. Divert 240 nmi (2nd std.) - 2000
40. Divert 240 nmi (2nd std.) + 4000
41. Divert 180 nmi (2nd comp.) - 3000
42. Divert 120 nmi (Adj. std.) - 4000
43. Divert 240 nmi (2nd std.) - 4000
44. Hold 12 min.
45. Divert 60 nmi (Adj. comp.) - 5000
46. Divert 180 nmi (2nd comp.) - 5000
47. Hold 18 min.
48. Divert 120 nmi (Adj. std.) - 6000
49. Divert 240 nmi (2nd std.) - 6000
50. Hold 24 min.
51. Descend 8000
52. Descend 1000
53. Hold 60 min.

Note: Options 1 through 33 are based on the priority ordering reported by the Gander ACC; the remaining options are extrapolations of the Gander ACC's priorities.

Shanwick OACC Westbound OTS Conflict Resolution Strategies for 120-60 nmi Lateral/2000 ft Vertical Composite Minima (Baseline System) For Aircraft in Flight

1. Lose up to 2 min. (by ocean entry)
2. Climb 2000
3. Climb 2000 & lose 2 min.
4. Climb 2000 & -M.01
5. Climb 2000 & lose 2 min. & -M0.01
6. Divert 60 nmi (Adj. comp.) + 1000
7. Divert 60 nmi (Adj. comp.) + 1000 & lose 2 min.
8. -M0.01
9. Divert 60 nmi (Adj. comp.) + 1000 & -M0.01
10. Lose 2 min. & -M0.01
11. Divert 60 nmi (Adj. comp.) + 1000 & lose 2 min. & -M0.01
12. Divert 60 nmi (Adj. comp.) - 1000
13. Divert 60 nmi (Adj. comp.) - 1000 & lose 2 min.
14. Divert 60 nmi (Adj. comp.) - 1000 & -M0.01
15. Divert 60 nmi (Adj. comp.) - 1000 & lose 2 min. & -M0.01
16. Descend 2000
17. Descend 2000 & lose 2 min.
18. Descend 2000 & -M0.01
19. Descend 2000 & lose 2 min. & -M0.01
20. Divert 120 nmi (Adj. std.)
21. Divert 120 nmi (Adj. std.) & lose 2 min.
22. Divert 120 nmi (Adj. std.) & -M0.01
23. Divert 120 nmi (Adj. std.) & lose 2 min. & -M0.01
24. Divert 120 nmi (Adj. std.) + 2000
25. Divert 120 nmi (Adj. std.) + 2000 & lose 2 min.
26. Divert 120 nmi (Adj. std.) + 2000 & -M0.01
27. Divert 120 nmi (Adj. std.) + 2000 & lose 2 min. & -M0.01
28. Divert 120 nmi (Adj. std.) - 2000
29. Divert 120 nmi (Adj. std.) - 2000 & lose 2 min.
30. Divert 120 nmi (Adj. std.) - 2000 & -M0.01
31. Divert 120 nmi (Adj. std.) - 2000 & lose 2 min. & -M0.01
32. Divert 60 nmi (Adj. comp.) + 3000
33. Divert 60 nmi (Adj. comp.) + 3000 & lose 2 min.

(Continued)

34. Divert 60 nmi (Adj. comp.) + 3000 & -M0.01
35. Divert 60 nmi (Adj. comp.) + 3000 & lose 2 min. & -M0.01
36. Divert 60 nmi (Adj. comp.) - 3000
37. Divert 60 nmi (Adj. comp.) - 3000 & lose 2 min.
38. Divert 60 nmi (Adj. comp.) - 3000 & -M0.01
39. Divert 60 nmi (Adj. comp.) - 3000 & lose 2 min. & -M0.01
40. Climb 4000
41. Descend 4000
42. Descend 4000 & lose 2 min.
43. Descend 4000 & -M0.01
44. Descend 4000 & lose 2 min. & -M0.01
45. Divert 180 nmi (2nd comp.) + 1000
46. Divert 180 nmi (2nd comp.) - 1000
47. Divert 240 nmi (2nd std.)
48. Divert 240 nmi (2nd std.) + 2000
49. Divert 240 nmi (2nd std.) - 2000
50. Divert 180 nmi (2nd comp.) + 3000
51. Divert 180 nmi (2nd comp.) - 3000
52. Divert 120 nmi (Adj. std.) + 4000
53. Divert 120 nmi (Adj. std.) - 4000
54. Divert 240 nmi (2nd std.) + 4000
55. Divert 240 nmi (2nd std.) - 4000
56. Hold 6 min.
57. Divert 60 nmi (Adj. comp.) - 5000
58. Divert 180 nmi (2nd comp.) - 5000
59. Hold 12 min.
60. Descend 6000
61. Divert 120 nmi (Adj. std.) - 6000
62. Divert 240 nmi (2nd std.) - 6000
63. Hold 24 min.
64. Descend 8000
65. Descend 10,000
66. Hold 60 min.

Note: Options 1 through 44 are based on the priority ordering reported by the CAA, UK; the remaining options are extrapolations of the CAA's priorities.

Gander ACC Random Traffic Conflict Resolution Strategies for 120-60 nmi Lateral/2000 ft Vertical Composite Minima (Baseline System) For Aircraft in Flight

1. Climb 2000
2. Descend 2000
3. -M.01
4. Climb 4000
5. Climb 2000 & -M.01
6. Descend 2000 & -M.01
7. Reroute 60 NM (laterally)
8. Climb 2000 & reroute 60 NM
9. Lose 2 min. (before ocean entry point)
10. Reroute 60 NM & -M.01
11. Climb 2000 & reroute 60 NM & -M.01
12. Descend 2000 & reroute 60 NM
13. Climb 2000 & lose 2 min.
14. Lose 2 min. & -M.01
15. Climb 2000 & lose 2 min. & -M.01
16. Climb 4000 & -M.01
17. Descend 2000 & lose 2 min.
18. Climb 4000 & reroute 60 NM
19. Descend 4000
20. Reroute 120 NM
21. Climb 4000 & lose 2 min.
22. Climb 2000 & reroute 120 NM
23. Reroute 120 NM & -M.01
24. Descend 4000 & reroute 60 NM
25. Climb 4000 & lose 2 min. & -M.01
26. Climb 2000 & reroute 120 NM & -M.01
27. +M.01
28. Hold 12 min.
29. Descend 6000
30. Hold 24 min.
31. Descend 8000
32. Descend 10,000
33. Hold 60 min.

Note: Options 1 through 29 are based on the priority ordering reported by the Gander ACC.

Shanwick OACC Westbound Random Track Conflict Resolution Strategies for 120-60 nmi Lateral/2000 ft Vertical Composite Minima (Baseline System) for Aircraft in Flight

1. Climb 2000
2. Reroute 60 nmi (laterally)
3. Reroute 60 nmi + 2000
4. Climb 2000 & -M0.01
5. -M0.01
6. Reroute 60 nmi & -M0.01
7. Reroute 60 nmi + 2000 & -M0.01
8. Descend 2000
9. Reroute 60 nmi - 2000
10. Reroute 60 nmi - 2000 & -M0.01
11. Descend 2000 & -M0.01
12. Climb 4000
13. Reroute 120 nmi
14. Descend 4000
15. Hold 12 min.
16. Descend 6000
17. Hold 24 min.
18. Descend 8000
19. Descend 10,000
20. Hold 60 min.

Note: Options 1 through 10 are based on the priority ordering reported by the CAA, UK; the remaining options are extrapolations of the CAA's priorities.

GANDER ACC EASTBOUND OTS CONFLICT RESOLUTION STRATEGIES FOR 120-60 NMI LATERAL 2,000 FT VERTICAL COMPOSITE MINIMA (BASELINE SYSTEM) FOR AIRCRAFT AT COASTAL AIRPORTS

1. Hold 10 min. (on ground)
2. Climb 2000
3. Descend 2000
4. -M.01
5. Climb 4000
6. Divert 60 nmi (Adj. comp.) + 1000
7. Divert 60 nmi (Adj. comp.) - 1000
8. Climb 2000 & -M.01
9. Descend 2000 & -M.01
10. Hold 20 min. (on ground)
11. Divert 60 nmi (Adj. comp.) + 3000
12. Divert 60 nmi (Adj. comp.) + 1000 & -M.01
13. Divert 60 nmi (Adj. comp.) - 1000 & -M.01
14. Divert 120 nmi (Adj. std.)
15. Divert 120 nmi (Adj. std.) & climb 2000
16. Divert 120 nmi (Adj. std.) & descend 2000
17. Divert 120 nmi (Adj. std.) & -M.01
18. Divert 120 nmi (Adj. std.) & climb 4000
19. Divert 120 nmi (Adj. std.) & climb 2000 & -M.01
20. Divert 60 nmi (Adj. comp.) + 3000 & -M.01
21. Divert 120 nmi (Adj. std.) & descend 2000 & -M.01
22. Climb 2000 & lose 2 min.
23. Descend 2000 & lose 2 min.
24. Climb 2000 & lose 2 min. & -M.01
25. Descend 2000 & lose 2 min. & -M.01
26. Climb 4000 & -M.01
27. Divert 60 nmi (Adj. comp.) - 3000
28. Descend 4000
29. Climb 4000 & lose 2 min.
30. Climb 4000 & lose 2 min. & -M.01
31. +M.01
32. Hold 30 min. (on ground)

Continued

33. Descend 6000
34. Divert 180 nmi (2nd comp.) + 1000
35. Divert 180 nmi (2nd comp.) - 1000
36. Divert 180 nmi (2nd comp.) + 3000
37. Divert 240 nmi (2nd std.)
38. Divert 240 nmi (2nd std.) + 2000
39. Divert 240 nmi (2nd std.) - 2000
40. Divert 240 nmi (2nd std.) + 4000
41. Divert 180 nmi (2nd comp.) - 3000
42. Divert 120 nmi (Adj. std.) - 4000
43. Divert 240 nmi (2nd std.) - 4000
44. Divert 60 nmi (Adj. comp.) - 5000
45. Divert 180 nmi (2nd comp.) - 5000
46. Divert 120 nmi (Adj. std.) - 6000
47. Divert 240 nmi (2nd std.) - 6000
48. Hold 45 min. (on ground)
49. Descend 8000
50. Descend 10,000
51. Hold 90 min. (on ground)

SHANWICK OACC WESTBOUND OTS CONFLICT RESOLUTION STRATEGIES FOR 120-60 NMI LATERAL/2000 FT VERTICAL COMPOSITE MINIMA (BASELINE SYSTEM) FOR AIRCRAFT AT COASTAL AIRPORTS

1. Hold 10 min. (on ground)
2. Climb 2000
3. Climb 2000 & lose 2 min.
4. Climb 2000 & -M.01
5. Climb 2000 & lose 2 min. & -M0.01
6. Divert 60 nmi (Adj. comp.) + 1000
7. Divert 60 nmi (Adj. comp.) + 1000 & lose 2 min.
8. -M0.01
9. Divert 60 nmi (Adj. comp.) + 1000 & -M0.01
10. Hold 20 min. (on ground)
11. Divert 60 nmi (Adj. comp.) + 1000 & lose 2 min. & -M0.01
12. Divert 60 nmi (Adj. comp.) - 1000
13. Divert 60 nmi (Adj. comp.) - 1000 & lose 2 min.
14. Divert 60 nmi (Adj. comp.) - 1000 & -M0.01
15. Divert 60 nmi (Adj. comp.) - 1000 & lose 2 min. & -M0.01
16. Descend 2000
17. Descend 2000 & lose 2 min.
18. Descend 2000 & -M0.01
19. Descend 2000 & lose 2 min. & -M0.01
20. Divert 120 nmi (Adj. std.)
21. Divert 120 nmi (Adj. std.) & lose 2 min.
22. Divert 120 nmi (Adj. std.) & -M0.01
23. Divert 120 nmi (Adj. std.) & lose 2 min. & -M0.01
24. Divert 120 nmi (Adj. std.) + 2000
25. Divert 120 nmi (Adj. std.) + 2000 & lose 2 min.
26. Divert 120 nmi (Adj. std.) + 2000 & -M0.01
27. Divert 120 nmi (Adj. std.) + 2000 & lose 2 min. & -M0.01
28. Divert 120 nmi (Adj. std.) - 2000
29. Divert 120 nmi (Adj. std.) - 2000 & lose 2 min.
30. Divert 120 nmi (Adj. std.) - 2000 & -M0.01
31. Divert 120 nmi (Adj. std.) - 2000 & lose 2 min. & -M0.01
32. Hold 30 min. (on ground)
33. Divert 60 nmi (Adj. comp.) + 3000
34. Divert 60 nmi (Adj. comp.) + 3000 & lose 2 min.

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35. Divert 60 nmi (Adj. comp.) + 3000 & -M0.01
36. Divert 60 nmi (Adj. comp.) + 3000 & lose 2 min. & -M0.01
37. Divert 60 nmi (Adj. comp.) - 3000
38. Divert 60 nmi (Adj. comp.) - 3000 & lose 2 min.
39. Divert 60 nmi (Adj. comp.) - 3000 & -M0.01
40. Divert 60 nmi (Adj. comp.) - 3000 & lose 2 min. & -M0.01
41. Climb 4000
42. Descend 4000
43. Descend 4000 & lose 2 min.
44. Descend 4000 & -M0.01
45. Descend 4000 & lose 2 min. & -M0.01
46. Divert 180 nmi (2nd comp.) + 1000
47. Divert 180 nmi (2nd comp.) - 1000
48. Divert 240 nmi (2nd std.)
49. Divert 240 nmi (2nd std.) + 2000
50. Divert 240 nmi (2nd std.) - 2000
51. Divert 180 nmi (2nd comp.) + 3000
52. Divert 180 nmi (2nd comp.) - 3000
53. Divert 120 nmi (Adj. std.) + 4000
54. Divert 120 nmi (Adj. std.) - 4000
55. Divert 240 nmi (2nd std.) + 4000
56. Divert 240 nmi (2nd std.) - 4000
57. Divert 60 nmi (Adj. comp.) - 5000
58. Divert 180 nmi (2nd comp.) - 5000
59. Descend 6000
60. Divert 120 nmi (Adj. std.) - 6000
61. Divert 240 nmi (2nd std.) - 6000
62. Hold 45 min. (on ground
63. Descend 8000
64. Descend 10,000
65. Hold 90 min. (on ground)

GANDER ACC RANDOM TRAFFIC CONFLICT RESOLUTION STRATEGIES FOR 120-60 NMI LATERAL/2000 FT VERTICAL COMPOSITE MINIMA (BASELINE SYSTEM) FOR AIRCRAFT AT COASTAL AIRPORTS

1. Hold 10 min. (on ground)
2. Climb 2000
3. Descend 2000
4. -M.01
5. Climb 4000
6. Climb 2000 & -M.01
7. Descend 2000 & -M.01
8. Reroute 60 NM (laterally)
9. Climb 2000 & reroute 60 NM
10. Hold 20 min. (on ground)
11. Reroute 60 NM & -M.01
12. Climb 2000 & reroute 60 NM & -M.01
13. Descend 2000 & reroute 60 NM
14. Climb 2000 & lose 2 min.
15. Hold 30 min. (on ground)
16. Climb 2000 & lose 2 min. & -M.01
17. Climb 4000 & -M.01
18. Descend 2000 & lose 2 min.
19. Climb 4000 & reroute 60 NM
20. Descend 4000
21. Reroute 120 NM
22. Climb 4000 & lose 2 min.
23. Climb 2000 & reroute 120 NM
24. Reroute 120 NM & -M.01
25. Descend 4000 & reroute 60 NM
26. Climb 4000 & lose 2 min. & -M.01
27. Climb 2000 & reroute 120 NM & -M.01
28. +M.01
29. Descend 6000
30. Hold 45 min. (on ground
31. Descend 8000
32. Descend 10,000
33. Hold 90 min. (on ground)

SHANWICK OACC WESTBOUND RANDOM TRACK CONFLICT RESOLUTION STRATEGIES
FOR 120-60 NMI LATERAL/2000 FT VERTICAL COMPOSITE
FOR AIRCRAFT AT COASTAL AIRPORTS

1. Hold 10 min. (on ground)
2. Climb 2000
3. Reroute 60 nmi (laterally)
4. Reroute 60 nmi + 2000
5. Climb 2000 & -M0.01
6. -M0.01
7. Hold 20 min. (on ground)
8. Reroute 60 nmi & -M0.01
9. Reroute 60 nmi + 2000 & -M0.01
10. Descend 2000
11. Reroute 60 nmi - 2000
12. Reroute 60 nmi - 2000 & -M0.01
13. Descend 2000 & -M0.01
14. Hold 30 min. (on ground
15. Climb 4000
16. Reroute 120 nmi
17. Descent 4000
18. Descend 6000
19. Hold 45 min. (on ground)
20. Descend 8000
21. Descend 10,000
22. Hold 90 min. (on ground)

OTS CONFLICT RESOLUTION STRATEGIES FOR 60 NMI
LATERAL/2000 FT VERTICAL MINIMA
FOR AIRCRAFT IN FLIGHT

1. Lose up to 2 min. (by oceanic entry)
2. Climb 2000
3. -M.01
4. Climb 2000 & lose 2 min.
5. Climb 2000 & -M .01
6. Climb 2000 & lose 2 min. & -M.01
7. Divert 60 nmi (1 track)
8. Divert 60 nmi (1 track) & lose 2 min.
9. Divert 60 nmi (1 track) & -M.01
10. Lose 2 min. & -M.01
11. Divert 60 nmi (1 track) & lose 2 min. & -M.01
12. Descend 2000
13. Descend 2000 & lose 2 min.
14. Descend 2000 & -M.01
15. Descend 2000 & lose 2 min. & -M.01
16. Climb 4000
17. Divert 60 nmi (1 track) + 2000
18. Divert 60 nmi (1 track) + 2000 & lose 2 min.
19. Divert 60 nmi (1 track) + 2000 & -M.01
20. Divert 60 nmi (1 track) + 2000 & lose 2 min. & -M.01
21. Divert 120 nmi (2 tracks)
22. Divert 120 nmi (2 tracks) & lose 2 min.
23. Divert 120 nmi (2 tracks) & -M.01
24. Divert 120 nmi (2 tracks) & lose 2 min. & -M.01
25. Divert 60 nmi (1 track) - 2000
26. Divert 60 nmi (1 track) - 2000 & lose 2 min.
27. Divert 60 nmi (1 track) - 2000 & -M.01
28. Divert 60 nmi (1 track) - 2000 & lose 2 min. - M.01
29. Divert 60 nmi (1 track) + 4000
30. Divert 120 nmi (2 tracks) + 2000

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31. Divert 120 nmi (2 tracks) + 2000 & lose 2 min.
32. Divert 120 nmi (2 tracks) + 2000 & -M.01
33. Divert 120 nmi (2 tracks) + 2000 & lose 2 min. & -M.01
34. Divert 120 nmi (2 tracks) - 2000
35. Divert 120 nmi (2 tracks) - 2000 & lose 2 min.
36. Divert 120 nmi (2 tracks) - 2000 & - M.01
37. Divert 120 nmi (2 tracks) - 2000 & lose 2 min. & -M.01
38. Divert 120 nmi (2 tracks) + 4000
39. Descend 4000
40. Descend 4000 & lose 2 min.
41. Descend 4000 & -M.01
42. Descend 4000 & lose 2 min. & -M.01
43. Divert 180 nmi (3 tracks)
44. Divert 180 nmi (3 tracks) + 2000
45. Divert 180 nmi (3 tracks) - 2000
46. Divert 180 nmi (3 tracks) + 4000
47. Divert 240 nmi (3 tracks)
48. Divert 240 nmi (3 tracks) + 2000
49. Divert 240 nmi (3 tracks) - 2000
50. Divert 240 nmi (3 tracks) + 4000
51. Divert 60 nmi (1 track) - 4000
52. Divert 120 nmi (2 tracks) - 4000
53. Divert 180 nmi (3 tracks) - 4000
54. Divert 240 nmi (4 tracks) - 4000
55. Hold 12 min.
56. Descend 6000
57. Divert 60 nmi (1 track) - 6000
58. Divert 120 nmi (2 tracks) - 6000
59. Divert 180 nmi (3 tracks) - 6000
60. Divert 240 nmi (4 tracks) - 6000
61. Hold 24 min.
62. Descend 8000
63. Descend 10,000
64. Hold 60 min.

RANDOM TRACK CONFLICT RESOLUTION STRATEGIES
FOR 60 NMI LATERAL/2000 FT VERTICAL MINIMA
FOR AIRCRAFT IN FLIGHT

1. Climb 2000
2. -M.01
3. Climb 2000 & -M.01
4. Reroute 60 nmi (laterally)
5. Reroute 60 nmi & -M.01
6. Descend 2000
7. Descend 2000 & -M.01
8. Reroute 60 nmi + 2000
9. Reroute 60 nmi + 2000 & -M.01
10. Lose 2 min. (before oceanic entry)
11. Climb 2000 & lose 2 min.
12. Climb 2000 & -M.01 & lose 2 min.
13. Reroute 60 nmi & lose 2 min.
14. Reroute 60 nmi & -M.01 & lose 2 min.
15. Reroute 60 nmi + 2000 & lose 2 min.
16. Reroute 60 nmi + 2000 & -M.01 & lose 2 min.
17. Climb 4000
18. Reroute 60 nmi - 2000
19. Reroute 60 nmi - 2000 & -M.01
20. Reroute 60 nmi - 2000 & lose 2 min.
21. Reroute 60 nmi - 2000 & -M.01 & lose 2 min.
22. Reroute 120 nmi
23. Reroute 120 nmi + 2000
24. Reroute 120 nmi - 2000
25. Descend 4000
26. Hold 12 min.
27. Descend 6000
28. Hold 24 min.
29. Descend 8000
30. Descend 10,000
31. Hold 60 min.

OTS CONFLICT RESOLUTION STRATEGIES FOR 60 NMI LATERAL/2000 FT VERTICAL MINIMA FOR AIRCRAFT AT COASTAL AIRPORTS

1. Hold 10 min (on ground)
2. Climb 2000
3. -M.01
4. Climb 2000 & lose 2 min.
5. Climb 2000 & -M.01
6. Climb 2000 & lose 2 min. & -M.01
7. Divert 60 nmi (1 track)
8. Divert 60 nmi (1 track) & lose 2 min.
9. Divert 60 nmi (1 track) & -M.01
10. Hold 20 min. (on ground)
11. Divert 60 nmi (1 track) & lose 2 min. & -M.01
12. Descend 2000
13. Descend 2000 & lose 2 min.
14. Descend 2000 & -M.01
15. Descend 2000 & lose 2 min. & -M.01
16. Climb 4000
17. Divert 60 nmi (1 track) + 2000
18. Divert 60 nmi (1 track) + 2000 & lose 2 min.
19. Divert 60 nmi (1 track) + 2000 & -M.01
20. Divert 60 nmi (1 track) + 2000 & lose 2 min. & -M.01
21. Divert 120 nmi (2 tracks)
22. Divert 120 nmi (2 tracks) & lose 2 min.
23. Divert 120 nmi (2 tracks) & -M.01
24. Divert 120 nmi (2 tracks) & lose 2 min. & -M.01
25. Divert 60 nmi (1 track) - 2000
26. Divert 60 nmi (1 track) - 2000 & lose 2 min.
27. Divert 60 nmi (1 track) - 2000 & -M.01
28. Divert 60 nmi (1 track) - 2000 & lose 2 min. - M.01
29. Divert 60 nmi (1 track) + 4000
30. Divert 120 nmi (2 tracks) + 2000

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31. Divert 120 nmi (2 tracks) + 2000 & lose 2 min.
32. Divert 120 nmi (2 tracks) + 2000 & -M.01
33. Divert 120 nmi (2 tracks) + 2000 & lose 2 min. & -M.01
34. Divert 120 nmi (2 tracks) - 2000
35. Divert 120 nmi (2 tracks) - 2000 & lose 2 min.
36. Divert 120 nmi (2 tracks) - 2000 & - M.01
37. Divert 120 nmi (2 tracks) - 2000 & lose 2 min. & -M.01
38. Hold 30 min. (on ground)
39. Divert 120 nmi (2 tracks) + 4000
40. Descend 4000
41. Descend 4000 & lose 2 min.
42. Descend 4000 & -M.01
43. Descend 4000 & lose 2 min. & -M.01
44. Divert 180 nmi (3 tracks)
45. Divert 180 nmi (3 tracks) + 2000
46. Divert 180 nmi (3 tracks) - 2000
47. Divert 180 nmi (3 tracks) + 4000
48. Divert 240 nmi (3 tracks)
49. Divert 240 nmi (3 tracks) + 2000
50. Divert 240 nmi (3 tracks) - 2000
51. Divert 240 nmi (3 tracks) + 4000
52. Divert 60 nmi (1 track) - 4000
53. Divert 120 nmi (2 tracks) - 4000
54. Divert 180 nmi (3 tracks) - 4000
55. Divert 240 nmi (4 tracks) - 4000
56. Descend 6000
57. Divert 60 nmi (1 track) - 6000
58. Divert 120 nmi (2 tracks) - 6000
59. Divert 180 nmi (3 tracks) - 6000
60. Divert 240 nmi (4 tracks) - 6000
61. Hold for 45 min. (on ground)
62. Descend 8000
63. Descend 10,000
64. Hold 90 min. (on ground)

RANDOM TRACK CONFLICT RESOLUTION STRATEGIES FOR 60 NMI LATERAL/ 2000 FT VERTICAL MINIMA FOR AIRCRAFT AT COASTAL AIRPORTS

1. Hold 10 min. (on ground)
2. Climb 2000
3. -M.01
4. Climb 2000 & -M.01
5. Reroute 60 nmi (laterally)
6. Reroute 60 nmi & -M.01
7. Descend 2000
8. Descend 2000 & -M.01
9. Reroute 60 nmi + 2000
10. Reroute 60 nmi + 2000 & -M.01
11. Hold 20 min. (on ground)
12. Climb 2000 & lose 2 min.
13. Climb 2000 & -M.01 & lose 2 min.
14. Reroute 60 nmi & lose 2 min.
15. Reroute 60 nmi & -M.01 & lose 2 min.
16. Reroute 60 nmi + 2000 & lose 2 min.
17. Reroute 60 nmi + 2000 & -M.01 & lose 2 min.
18. Climb 4000
19. Hold 30 min. (on ground)
20. Reroute 60 nmi - 2000
21. Reroute 60 nmi - 2000 & -M.01
22. Reroute 60 nmi - 2000 & lose 2 min.
23. Reroute 60 nmi - 2000 & -M.01 & lose 2 min.
24. Reroute 120 nmi
25. Reroute 120 nmi + 2000
26. Reroute 120 nmi - 2000
27. Descend 4000
28. Descend 6000
29. Hold 45 min. (on ground)
30. Descend 8000
31. Descend 10,000
32. Hold 90 min. (on ground)

OTS CONFLICT RESOLUTION STRATEGIES FOR
30 NMI LATERAL/2000 FT VERTICAL MINIMA FOR
AIRCRAFT IN FLIGHT

1. Lose up to 2 min. (by oceanic entry)
2. Climb 2000
3. -M.01
4. Climb 2000 & lose 2 min.
5. Climb 2000 & -M.01
6. Climb 2000 & lose 2 min. & -M.01
7. Divert 30 min. (1 track)
8. Divert 30 min. (1 track) & lose 2 min.
9. Divert 30 min. (1 track) & -M.01
10. Lose 2 min. & -M.01
11. Divert 30 nmi (1 track) & lose 2 min. & -M.01
12. Divert 60 nmi (2 tracks)
13. Divert 60 nmi (2 tracks) & lose 2 min.
14. Divert 60 nmi (2 tracks) & -M.01
15. Divert 60 nmi (2 tracks) & lose 2 min & -M.01
16. Descend 2000
17. Descend 2000 & lose 2 min.
18. Descend 2000 & -M.01
19. Descend 2000 & lose 2 min. & -M.01
20. Climb 4000
21. Divert 30 nmi (1 track) + 2000
22. Divert 30 nmi (1 track) + 2000 & lose 2 min.
23. Divert 30 nmi (1 track) + 2000 & -M.01
24. Divert 30 nmi (1 track) + 2000 & lose 2 min. & -M.01
25. Divert 60 nmi (2 tracks) + 2000
26. Divert 60 nmi (2 tracks) + 2000 & lose 2 min.
27. Divert 60 nmi (2 tracks) + 2000 & -M.01
28. Divert 60 nmi (2 tracks) + 2000 & lose 2 min. & -M.01
29. Divert 90 nmi (3 tracks)
30. Divert 90 nmi (3 tracks) & lose 2 min.
31. Divert 90 nmi (3 tracks) & -M.01
32. Divert 90 nmi (3 tracks) & lose 2 min. & -M.01
33. Divert 120 nmi (4 tracks)

Continued

(2)

34. Divert 120 nmi (4 tracks) & lose 2 min.
35. Divert 120 nmi (4 tracks) & -M.01
36. Divert 120 nmi (4 tracks) & lose 2 min. & -M.01
37. Divert 30 nmi (1 track) - 2000
38. Divert 30 nmi (1 track) - 2000 & lose 2 min.
39. Divert 30 nmi (1 track) -2000 & -M.01
40. Divert 30 nmi (1 track) - 2000 & lose 2 min. & -M.01
41. Divert 60 nmi (2 tracks) - 2000
42. Divert 30 nmi (1 track) + 4000
43. Divert 60 nmi (2 tracks) + 4000
44. Divert 90 nmi (3 tracks) + 2000
45. Divert 120 nmi (4 tracks) + 2000
46. Divert 90 nmi (3 tracks) - 2000
47. Divert 120 nmi (4 tracks) - 2000
48. Divert 90 nmi (3 tracks) + 4000
49. Divert 120 nmi (4 tracks) + 4000
50. Descend 4000
51. Divert 150 nmi (5 tracks)
52. Divert 150 nmi (5 tracks) + 2000
53. Divert 150 nmi (5 tracks) - 2000
54. Divert 150 nmi (5 tracks) + 4000
55. Divert 180 nmi (6 tracks)
56. Divert 180 nmi (6 tracks) + 2000
57. Divert 180 nmi (6 tracks) - 2000
58. Divert 180 nmi (6 tracks) + 4000
59. Divert 210 nmi (7 tracks)
60. Divert 210 nmi (7 tracks) + 2000
61. Divert 210 nmi (7 tracks) - 2000
62. Divert 210 nmi (7 tracks) + 4000
63. Divert 240 nmi (8 tracks)
64. Divert 240 nmi (8 tracks) + 2000
65. Divert 240 nmi (8 tracks) - 2000
66. Divert 240 nmi (8 tracks) + 4000

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(3)

67. Divert 30 nmi (1 track) - 4000
68. Divert 60 nmi (2 tracks) - 4000
69. Divert 90 nmi (3 tracks) - 4000
70. Divert 120 nmi (4 tracks) - 4000
71. Divert 150 nmi (5 tracks) - 4000
72. Divert 180 nmi (6 tracks) - 4000
73. Divert 210 nmi (7 tracks) - 4000
74. Divert 240 nmi (8 tracks) - 4000
75. Hold 12 min.
76. Descend 6000
77. Divert 30 nmi (1 track) - 6000
78. Divert 60 nmi (2 tracks) - 6000
79. Divert 90 nmi (3 tracks) - 6000
80. Divert 120 nmi (4 tracks) - 6000
81. Divert 150 nmi (5 tracks) - 6000
82. Divert 180 nmi (6 tracks) - 6000
83. Divert 210 nmi (7 tracks) - 6000
84. Divert 240 nmi (8 tracks) - 6000
85. Hold 24 min.
86. Descend 8000
87. Descend 10,000
88. Hold 60 min.

RANDOM TRACK CONFLICT RESOLUTION STRATEGIES FOR
30 NMI LATERAL/2000 FT VERTICAL MINIMA FOR AIRCRAFT IN FLIGHT

1. Climb 2000
2. -M.01
3. Climb 2000 & -M.01
4. Reroute 30 nmi (laterally)
5. Reroute 30 nmi & -M.01
6. Descend 2000
7. Descend 2000 & -M.01
8. Reroute 30 nmi + 2000
9. Reroute 30 nmi + 2000 & -M.01
10. Lose 2 min. (before oceanic entry)
11. Climb 2000 & lose 2 min.
12. Climb 2000 & -M.01 & lose 2 min.
13. Climb 4000
14. Reroute 30 nmi & lose 2 min.
15. Reroute 30 nmi & -M.01 & lose 2 min.
16. Reroute 30 nmi + 2000 & lose 2 min.
17. Reroute 30 nmi + 2000 & -M.01 & lose 2 min.
18. Reroute 30 nmi - 2000
19. Reroute 30 nmi - 2000 & -M.01
20. Reroute 30 nmi - 2000 & lose 2 min.
21. Reroute 30 nmi - 2000 & -M.01 & lose 2 min.
22. Reroute 60 nmi
23. Reroute 60 nmi + 2000
24. Reroute 60 nmi - 2000
25. Descend 4000
26. Hold 12 min.
27. Descend 6000
28. Hold 24 min.
29. Descend 8000
30. Descend 10,000
31. Hold 60 min.

OTS CONFLICT RESOLUTION STRATEGIES FOR
30 NMI LATERAL/2000 FT VERTICAL MINIMA FOR
AIRCRAFT AT COASTAL AIRPORTS

1. Hold 10 min. (on ground)
2. Climb 2000
3. -M.01
4. Climb 2000 & lose 2 min.
5. Climb 2000 & -M.01
6. Climb 2000 & lose 2 min. & -M.01
7. Divert 30 min. (1 track)
8. Divert 30 min. (1 track) & lose 2 min.
9. Divert 30 min. (1 track) & -M.01
10. Hold 20 min. (on ground)
11. Divert 30 nmi (1 track) & lose 2 min. & -M.01
12. Divert 60 nmi (2 tracks)
13. Divert 60 nmi (2 tracks) & lose 2 min.
14. Divert 60 nmi (2 tracks) & -M.01
15. Divert 60 nmi (2 tracks) & lose 2 min & -M.01
16. Descend 2000
17. Descend 2000 & lose 2 min.
18. Descend 2000 & -M.01
19. Descend 2000 & lose 2 min. & -M.01
20. Climb 4000
21. Divert 30 nmi (1 track) + 2000
22. Divert 30 nmi (1 track) + 2000 & lose 2 min.
23. Divert 30 nmi (1 track) + 2000 & -M.01
24. Divert 30 nmi (1 track) + 2000 & lose 2 min. & -M.01
25. Divert 60 nmi (2 tracks) + 2000
26. Divert 60 nmi (2 tracks) + 2000 & lose 2 min.
27. Divert 60 nmi (2 tracks) + 2000 & -M.01
28. Divert 60 nmi (2 tracks) + 2000 & lose 2 min. & -M.01
29. Divert 90 nmi (3 tracks)
30. Divert 90 nmi (3 tracks) & lose 2 min.
31. Divert 90 nmi (3 tracks) & -M.01
32. Divert 90 nmi (3 tracks) & lose 2 min. & -M.01
33. Divert 120 nmi (4 tracks)

Continued

34. Divert 120 nmi (4 tracks) & lose 2 min.
35. Divert 120 nmi (4 tracks) & -M.01
36. Divert 120 nmi (4 tracks) & lose 2 min. & -M.01
37. Divert 30 nmi (1 track) - 2000
38. Divert 30 nmi (1 track) - 2000 & lose 2 min.
39. Divert 30 nmi (1 track) -2000 & -M.01
40. Divert 30 nmi (1 track) - 2000 & lose 2 min. & -M.01
41. Hold 30 min. (on ground)
42. Divert 60 nmi (2 tracks) - 2000
43. Divert 30 nmi (1 track) + 4000
44. Divert 60 nmi (2 tracks) + 4000
45. Divert 90 nmi (3 tracks) + 2000
46. Divert 120 nmi (4 tracks) + 2000
47. Divert 90 nmi (3 tracks) - 2000
48. Divert 120 nmi (4 tracks) - 2000
49. Divert 90 nmi (3 tracks) + 4000
50. Divert 120 nmi (4 tracks) + 4000
51. Descend 4000
52. Divert 150 nmi (5 tracks)
53. Divert 150 nmi (5 tracks) + 2000
54. Divert 150 nmi (5 tracks) - 2000
55. Divert 150 nmi (5 tracks) + 4000
56. Divert 180 nmi (6 tracks)
57. Divert 180 nmi (6 tracks) + 2000
58. Divert 180 nmi (6 tracks) - 2000
59. Divert 180 nmi (6 tracks) + 4000
60. Divert 210 nmi (7 tracks)
61. Divert 210 nmi (7 tracks) + 2000
62. Divert 210 nmi (7 tracks) - 2000
63. Divert 210 nmi (7 tracks) + 4000
64. Divert 240 nmi (8 tracks)
65. Divert 240 nmi (8 tracks) + 2000
66. Divert 240 nmi (8 tracks) - 2000
67. Divert 240 nmi (8 tracks) + 4000

Continued

(3)

68. Divert 30 nmi (1 track) - 4000
69. Divert 60 nmi (2 tracks) - 4000
70. Divert 90 nmi (3 tracks) - 4000
71. Divert 120 nmi (4 tracks) - 4000
72. Divert 150 nmi (5 tracks) - 4000
73. Divert 180 nmi (6 tracks) - 4000
74. Divert 210 nmi (7 tracks) - 4000
75. Divert 240 nmi (8 tracks) - 4000
76. Descend 6000
77. Divert 30 nmi (1 track) - 6000
78. Divert 60 nmi (2 tracks) - 6000
79. Divert 90 nmi (3 tracks) - 6000
80. Divert 120 nmi (4 tracks) - 6000
81. Divert 150 nmi (5 tracks) - 6000
82. Divert 180 nmi (6 tracks) - 6000
83. Divert 210 nmi (7 tracks) - 6000
84. Divert 240 nmi (8 tracks) - 6000
85. Hold 45 min. (on ground)
86. Descend 8000
87. Descend 10,000
88. Hold 90 min. (on ground)

RANDOM TRACK CONFLICT RESOLUTION STRATEGIES FOR
30 NMI LATERAL/2000 FT VERTICAL MINIMA FOR AIRCRAFT AT COASTAL AIRPORTS

1. Hold 10 min. (on ground)
2. Climb 2000
3. -M.01
4. Climb 2000 & -M.01
5. Reroute 30 nmi (laterally)
6. Reroute 30 nmi & -M.01
7. Descend 2000
8. Descend 2000 & -M.01
9. Reroute 30 nmi + 2000
10. Reroute 30 nmi + 2000 & -M.01
11. Hold 20 min. (on ground)
12. Climb 2000 & lose 2 min.
13. Climb 2000 & -M.01 & lose 2 min.
14. Climb 4000
15. Hold 30 min. (on ground)
16. Reroute 30 nmi & lose 2 min.
17. Reroute 30 nmi & -M.01 & lose 2 min.
18. Reroute 30 nmi + 2000 & lose 2 min.
19. Reroute 30 nmi + 2000 & -M.01 & lose 2 min.
20. Reroute 30 nmi - 2000
21. Reroute 30 nmi - 2000 & -M.01
22. Reroute 30 nmi - 2000 & lose 2 min.
23. Reroute 30 nmi - 2000 & -M.01 & lose 2 min.
24. Reroute 60 nmi
25. Reroute 60 nmi + 2000
26. Reroute 60 nmi - 2000
27. Descend 4000
28. Descend 6000
29. Hold 45 min. (on ground)
30. Descend 8000
31. Descend 10,000
32. Hold 90 min. (on ground)

OTS CONFLICT RESOLUTION STRATEGIES FOR 60 NMI LATERAL/1000 FT VERTICAL MINIMA FOR AIRCRAFT IN FLIGHT

1. Lose up to 2 min. (by oceanic entry)
2. Climb 1000
3. -M.01
4. Climb 1000 & lose 2 min.
5. Climb 1000 & -M.01
6. Climb 1000 & lose 2 min. & -M.01
7. Climb 2000
8. Climb 2000 & lose 2 min.
9. Climb 2000 & -M.01
10. Climb 2000 & lose 2 min. & -M.01
11. Divert 60 nmi (1 track)
12. Divert 60 nmi (1 track) & lose 2 min.
13. Divert 60 nmi (1 track) & -M.01
14. Lose 2 min. & -M.01
15. Divert 60 nmi (1 track) & lose 2 min. & -M.01
16. Descend 1000
17. Descend 1000 & lose 2 min.
18. Descend 1000 & -M.01
19. Descend 1000 & lose 2 min. & -M.01
20. Descend 2000
21. Descend 2000 & lose 2 min.
22. Descend 2000 & -M.01
23. Descend 2000 & lose 2 min. & -M.01
24. Climb 3000
25. Climb 4000
26. Divert 60 nmi (1 track) + 1000
27. Divert 60 nmi (1 track) + 1000 & lose 2 min.
28. Divert 60 nmi (1 track) + 1000 & -M.01
29. Divert 60 nmi (1 track) + 1000 & lose 2 min. & -M.01
30. Divert 60 nmi (1 track) + 2000

Continued

(2)

31. Divert 60 nmi (1 track) + 2000 & lose 2 min.
32. Divert 60 nmi (1 track) + 2000 & -M.01
33. Divert 60 nmi (1 track) + 2000 & lose 2 min. & -M.01
34. Divert 120 nmi (2 tracks)
35. Divert 120 nmi (2 tracks) & lose 2 min.
36. Divert 120 nmi (2 tracks) & -M.01
37. Divert 120 nmi (2 tracks) & lose 2 min. & -M.01
38. Divert 60 nmi (1 track) - 1000
39. Divert 60 nmi (1 track) - 2000
40. Divert 60 nmi (1 track) + 3000
41. Divert 60 nmi (1 track) + 4000
42. Divert 120 nmi (2 tracks) + 1000
43. Divert 120 nmi (2 tracks) + 2000
44. Divert 120 nmi (2 tracks) - 1000
45. Divert 120 nmi (2 tracks) - 2000
46. Divert 120 nmi (2 tracks) + 3000
47. Divert 120 nmi (2 tracks) + 4000
48. Descend 3000
49. Descend 4000
50. Divert 180 nmi (3 tracks)
51. Divert 180 nmi (3 tracks) + 1000
52. Divert 180 nmi (3 tracks) + 2000
53. Divert 180 nmi (3 tracks) - 1000
54. Divert 180 nmi (3 tracks) - 2000
55. Divert 180 nmi (3 tracks) + 3000
56. Divert 180 nmi (3 tracks) + 4000
57. Divert 240 nmi (3 tracks)
58. Divert 240 nmi (3 tracks) + 1000
59. Divert 240 nmi (3 tracks) + 2000
60. Divert 240 nmi (3 tracks) - 1000
61. Divert 240 nmi (3 tracks) - 2000
62. Divert 240 nmi (3 tracks) + 3000
63. Divert 240 nmi (3 tracks) + 4000

Continued

64. Divert 60 nmi (1 track) - 3000
65. Divert 120 nmi (2 tracks) - 3000
66. Divert 180 nmi (3 tracks) - 3000
67. Divert 240 nmi (4 tracks) - 3000
68. Divert 60 nmi (1 track) - 4000
69. Divert 120 nmi (2 tracks) - 4000
70. Divert 180 nmi (3 tracks) - 4000
71. Divert 240 nmi (4 tracks) - 4000
72. Hold 6 min.
73. Descend 5000
74. Divert 60 nmi (1 track) - 5000
75. Divert 120 nmi (2 tracks) - 5000
76. Divert 180 nmi (3 tracks) - 5000
77. Divert 240 nmi (4 tracks) - 5000
78. Hold 12 min.
79. Descend 6000
80. Divert 60 nmi (1 track) - 6000
81. Divert 120 nmi (2 tracks) - 6000
82. Divert 180 nmi (3 tracks) - 6000
83. Divert 240 nmi (4 tracks) - 6000
84. Hold 24 min.
85. Descend 7000
86. Descend 8000
87. Descend 9000
88 Descend 10,000
89. Hold 60 min.

RANDOM TRACK CONFLICT RESOLUTION STRATEGIES
FOR 60 NMI LATERAL/1000 VERTICAL MINIMA
FOR AIRCRAFT IN FLIGHT

1. Climb 1000
2. Climb 2000
3. -M.01
4. Climb 1000 & -M.01
5. Climb 2000 & -M.01
6. Reroute 60 nmi (laterally)
7. Reroute 60 nmi & -M.01
8. Descend 1000
9. Descend 1000 & -M.01
10. Descend 2000
11. Descend 2000 & -M.01
12. Reroute 60 nmi + 1000
13. Reroute 60 nmi + 1000 & -M.01
14. Lose 2 min. (before oceanic entry)
15. Climb 1000 & lose 2 min.
16. Climb 2000 & lose 2 min.
17. Climb 1000 & -M.01 & lose 2 min.
18. Climb 2000 & -M.01 & lose 2 min.
19. Climb 3000
20. Climb 4000
21. Reroute 60 nmi & lose 2 min.
22. Reroute 60 nmi & -M.01 & lose 2 min.
23. Reroute 60 nmi + 1000 & lose 2 min.
24. Reroute 60 nmi + 1000 & -M.01 & lose 2 min.
25. Reroute 60 nmi + 2000
26. Reroute 60 nmi + 2000 & -M.01
27. Reroute 60 nmi + 2000 & lose 2 min.
28. Reroute 60 nmi + 2000 & -M.01 & lose 2 min.
29. Reroute 60 nmi - 1000
30. Reroute 60 nmi - 2000
31. Reroute 120 nmi
32. Descend 3000
33. Descend 4000

Continued

34. Hold 6 min.
35. Descend 5000
36. Hold 12 min.
37. Descend 6000
38. Hold 24 min.
39. Descend 7000
40. Descend 8000
41. Descend 9000
42. Descend 10,000
43. Hold 60 min.

AD-A123 833 OCEANIC AREA SYSTEM IMPROVEMENT STUDY (OASIS) VOLUME IX 2/2
FLIGHT COST MODEL..(U) SRI INTERNATIONAL MENLO PARK CA
K Y WANG ET AL. SEP 81 OASIS-FCM FAA-EM-81-17-9
UNCLASSIFIED DOT-FA79WA-4265 F/G 9/2 NL

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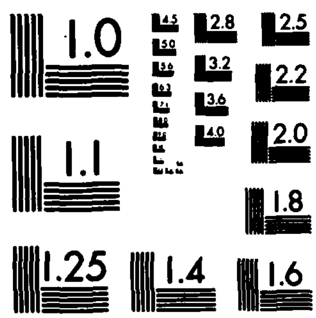

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

OTS CONFLICT RESOLUTION STRATEGIES FOR 60 NMI LATERAL/1000 FT VERTICAL MINIMA FOR AIRCRAFT AT COASTAL AIRPORTS

1. Hold 10 min. (on ground)
2. Climb 1000
3. -M.01
4. Climb 1000 & lose 2 min.
5. Climb 1000 & -M.01
6. Climb 1000 & lose 2 min. & -M.01
7. Climb 2000
8. Climb 2000 & lose 2 min.
9. Climb 2000 & -M.01
10. Climb 2000 & lose 2 min. & -M.01
11. Divert 60 nmi (1 track)
12. Divert 60 nmi (1 track) & lose 2 min.
13. Divert 60 nmi (1 track) & -M.01
14. Hold 20 min. (on ground)
15. Divert 60 nmi (1 track) & lose 2 min. & -M.01
16. Descend 1000
17. Descend 1000 & lose 2 min.
18. Descend 1000 & -M.01
19. Descend 1000 & lose 2 min. & -M.01
20. Descend 2000
21. Descend 2000 & lose 2 min.
22. Descend 2000 & -M.01
23. Descend 2000 & lose 2 min. & -M.01
24. Climb 3000
25. Climb 4000
26. Divert 60 nmi (1 track) + 1000
27. Divert 60 nmi (1 track) + 1000 & lose 2 min.
28. Divert 60 nmi (1 track) + 1000 & -M.01
29. Divert 60 nmi (1 track) + 1000 & lose 2 min. & -M.01
30. Divert 60 nmi (1 track) + 2000

Continued

31. Divert 60 nmi (1 track) + 2000 & lose 2 min.
32. Divert 60 nmi (1 track) + 2000 & -M.01
33. Divert 60 nmi (1 track) + 2000 & lose 2 min. & -M.01
34. Divert 120 nmi (2 tracks)
35. Divert 120 nmi (2 tracks) & lose 2 min.
36. Divert 120 nmi (2 tracks) & -M.01
37. Divert 120 nmi (2 tracks) & lose 2 min. & -M.01
38. Hold 30 min. (on ground)
39. Divert 60 nmi (1 track) - 1000
40. Divert 60 nmi (1 track) - 2000
41. Divert 60 nmi (1 track) + 3000
42. Divert 60 nmi (1 track) + 4000
43. Divert 120 nmi (2 tracks) + 1000
44. Divert 120 nmi (2 tracks) + 2000
45. Divert 120 nmi (2 tracks) - 1000
46. Divert 120 nmi (2 tracks) - 2000
47. Divert 120 nmi (2 tracks) + 3000
48. Divert 120 nmi (2 tracks) + 4000
49. Descend 3000
50. Descend 4000
51. Divert 180 nmi (3 tracks)
52. Divert 180 nmi (3 tracks) + 1000
53. Divert 180 nmi (3 tracks) + 2000
54. Divert 180 nmi (3 tracks) - 1000
55. Divert 180 nmi (3 tracks) - 2000
56. Divert 180 nmi (3 tracks) + 3000
57. Divert 180 nmi (3 tracks) + 4000
58. Divert 240 nmi (3 tracks)
59. Divert 240 nmi (3 tracks) + 1000
60. Divert 240 nmi (3 tracks) + 2000
61. Divert 240 nmi (3 tracks) - 1000
62. Divert 240 nmi (3 tracks) - 2000
63. Divert 240 nmi (3 tracks) + 3000
64. Divert 240 nmi (3 tracks) + 4000

Continued

65. Divert 60 nmi (1 track) - 3000
66. Divert 120 nmi (2 tracks) - 3000
67. Divert 180 nmi (3 tracks) - 3000
68. Divert 240 nmi (4 tracks) - 3000
69. Divert 60 nmi (1 track) - 4000
70. Divert 120 nmi (2 tracks) - 4000
71. Divert 180 nmi (3 tracks) - 4000
72. Divert 240 nmi (4 tracks) - 4000
73. Descend 5000
74. Divert 60 nmi (1 track) - 5000
75. Divert 120 nmi (2 tracks) - 5000
76. Divert 180 nmi (3 tracks) - 5000
77. Divert 240 nmi (4 tracks) - 5000
78. Descend 6000
79. Divert 60 nmi (1 track) - 6000
80. Divert 120 nmi (2 tracks - 6000
81. Divert 180 nmi (3 tracks) - 6000
82. Divert 240 nmi (4 tracks) - 6000
83. Hold 45 min. (on ground)
84. Descend 7000
85. Descend 8000
86. Descend 9000
87. Descend 10,000
88. Hold 90 min. (on ground)

RANDOM TRACK CONFLICT RESOLUTION STRATEGIES FOR 60 NMI LATERAL/1000 VERTICAL MINIMA FOR AIRCRAFT AT COASTAL AIRPORTS

1. Hold 10 min. (on ground)
2. Climb 1000
3. Climb 2000
4. -M.01
5. Climb 1000 & -M.01
6. Climb 2000 & -M.01
7. Reroute 60 nmi (laterally)
8. Reroute 60 nmi & -M.01
9. Descend 1000
10. Descend 1000 & -M.01
11. Descend 2000
12. Descend 2000 & -M.01
13. Reroute 60 nmi + 1000
14. Reroute 60 nmi + 1000 & -M.01
15. Hold 20 min. (on ground)
16. Climb 1000 & lose 2 min.
17. Climb 2000 & lose 2 min.
18. Climb 1000 & -M.01 & lose 2 min.
19. Climb 2000 & -M.01 & lose 2 min.
20. Climb 3000
21. Climb 4000
22. Hold 30 min. (on ground)
23. Reroute 60 nmi & lose 2 min.
24. Reroute 60 nmi & -M.01 & lose 2 min.
25. Reroute 60 nmi + 1000 & lose 2 min.
26. Reroute 60 nmi + 1000 & -M.01 & lose 2 min.
27. Reroute 60 nmi + 2000
28. Reroute 60 nmi + 2000 & -M.01
29. Reroute 60 nmi + 2000 & lose 2 min.
30. Reroute 60 nmi + 2000 & -M.01 & lose 2 min.
31. Reroute 60 nmi - 1000
32. Reroute 60 nmi - 2000
33. Reroute 120 nmi
34. Descend 3000

Continued

35. Descend 4000
36. Descend 5000
37. Descend 6000
38. Hold 45 min. (on ground)
39. Descend 7000
40. Descend 8000
41. Descend 9000
42. Descend 10,000
43. Hold 90 min. (on ground

OTS CONFLICT RESOLUTION STRATEGIES FOR 30 NMI
LATERAL/1000 FT VERTICAL MINIMA FOR AIRCRAFT IN FLIGHT
(this system was not analyzed by FCM in the OASIS project)

1. Lose up to 2 min. (by oceanic entry)
2. Climb 1000
3. -M.01
4. Climb 1000 & lose 2 min.
5. Climb 1000 & -M.01
6. Climb 1000 & lose 2 min. & -M.01
7. Climb 2000
8. Climb 2000 & lose 2 min.
9. Climb 2000 & -M.01
10. Climb 2000 & lose 2 min & -M.01
11. Divert 30 nmi (1 track)
12. Divert 30 nmi (1 track) & lose 2 min.
13. Divert 30 nmi (1 track) & -M.01
14. Lose 2 min. & -M.01
15. Divert 30 nmi (1 track) & lose 2 min. & -M.01
16. Divert 60 nmi (2 tracks)
17. Divert 60 nmi (2 tracks) & lose 2 min.
18. Divert 60 nmi (2 tracks) & -M.01
19. Divert 60 nmi (2 tracks) & lose 2 min. & -M.01
20. Descend 1000
21. Descend 1000 & lose 2 min.
22. Descend 1000 & -M.01
23. Descend 1000 & lose 2 min. & -M.01
24. Descend 6000
25. Descend 6000 & lose 2 min.
26. Descend 6000 & -M.01
27. Descend 6000 & lose 2 min. & -M.01
28. Climb 3000
29. Climb 4000
30. Divert 30 nmi + 1000
31. Divert 30 nmi + 1000 & lose 2 min.
32. Divert 30 nmi + 1000 & -M.01
33. Divert 30 nmi + 1000 & lose 2 min. & -M.01

Continued

34. Divert 30 nmi + 2000
35. Divert 30 nmi + 2000 & lose 2 min.
36. Divert 30 nmi + 2000 & -M.01
37. Divert 30 nmi + 2000 & lose 2 min. & -M.01
38. Divert 60 nmi (2 tracks) + 1000
39. Divert 60 nmi (2 tracks) + 2000
40. Divert 90 nmi (3 tracks)
41. Divert 120 nmi (4 tracks)
42. Divert 30 nmi (1 track) - 1000
43. Divert 30 nmi (1 track) - 2000
44. Divert 60 nmi (2 tracks) - 1000
45. Divert 60 nmi (2 tracks) - 2000
46. Divert 30 nmi (1 track) + 3000
47. Divert 30 nmi (1 track) + 4000
48. Divert 60 nmi (2 tracks) + 3000
49. Divert 60 nmi (2 tracks) + 4000
50. Divert 90 nmi (3 tracks) + 1000
51. Divert 90 nmi (3 tracks) + 2000
52. Divert 120 nmi (4 tracks) + 1000
53. Divert 120 nmi (4 tracks) + 2000
54. Divert 90 nmi (3 tracks) - 1000
55. Divert 90 nmi (3 tracks) - 2000
56. Divert 120 nmi (4 tracks) - 1000
57. Divert 120 nmi (4 tracks) - 2000
58. Divert 90 nmi (3 tracks) + 3000
59. Divert 90 nmi (3 tracks) + 4000
60. Divert 120 nmi (4 tracks) + 3000
61. Divert 120 nmi (4 tracks) + 4000
62. Descend 3000
63. Descend 4000
64. Divert 150 nmi (5 tracks)
65. Divert 150 nmi (5 tracks) + 1000
66. Divert 150 nmi (5 tracks) + 2000
67. Divert 150 nmi (5 tracks) - 1000
68. Divert 150 nmi (5 tracks) - 2000

Continued

(3)

69. Divert 150 nmi (5 tracks) + 3000
70. Divert 150 nmi (5 tracks) + 4000
71. Divert 180 nmi (6 tracks)
72. Divert 180 nmi (6 tracks) + 1000
73. Divert 180 nmi (6 tracks) + 2000
74. Divert 180 nmi (6 tracks) - 1000
75. Divert 180 nmi (6 tracks) - 2000
76. Divert 180 nmi (6 tracks) + 3000
77. Divert 180 nmi (6 tracks) + 4000
78. Divert 210 nmi (7 tracks)
79. Divert 210 nmi (7 tracks) + 1000
80. Divert 210 nmi (7 tracks) + 2000
81. Divert 210 nmi (7 tracks) - 1000
82. Divert 210 nmi (7 tracks) - 2000
83. Divert 210 nmi (7 tracks) + 3000
84. Divert 210 nmi (7 tracks) + 4000
85. Divert 240 nmi (8 tracks)
86. Divert 240 nmi (8 tracks) + 1000
87. Divert 240 nmi (8 tracks) + 2000
88. Divert 240 nmi (8 tracks) - 1000
89. Divert 240 nmi (8 tracks) - 2000
90. Divert 240 nmi (8 tracks) + 3000
91. Divert 240 nmi (8 tracks) + 4000
92. Divert 30 nmi (1 track) - 3000
93. Divert 60 nmi (2 tracks) - 3000
94. Divert 90 nmi (3 tracks) - 3000
95. Divert 120 nmi (4 tracks) - 3000
96. Divert 150 nmi (5 tracks) - 3000
97. Divert 180 nmi (6 tracks) - 3000
98. Divert 210 nmi (7 tracks) - 3000
99. Divert 240 nmi (8 tracks) - 3000
100. Divert 30 nmi (1 track) - 4000
101. Divert 60 nmi (2 tracks) - 4000
102. Divert 90 nmi (3 tracks) - 4000
103. Divert 120 nmi (4 tracks) - 4000
104. Divert 150 nmi (5 tracks) - 4000
105. Divert 180 nmi (6 tracks) - 4000

Continued

106. Divert 210 nmi (7 tracks) - 4000
107. Divert 240 nmi (8 tracks) - 4000
108. Hold 6 min.
109. Descend 5000
110. Divert 30 nmi (1 track) - 5000
111. Divert 60 nmi (2 tracks) - 5000
112. Divert 90 nmi (3 tracks) - 5000
113. Divert 120 nmi (4 tracks) - 5000
114. Divert 150 nmi (5 tracks) - 5000
115. Divert 180 nmi (6 tracks) - 5000
116. Divert 210 nmi (7 tracks) - 5000
117. Divert 240 nmi (8 tracks) - 5000
118. Hold 12 min.
119. Descend 6000
120. Divert 30 nmi (1 track) - 6000
121. Divert 60 nmi (2 tracks) - 6000
122. Divert 90 nmi (3 tracks) - 6000
123. Divert 120 nmi (4 tracks) - 6000
124. Divert 150 nmi (5 tracks) - 6000
125. Divert 180 nmi (6 tracks) - 6000
126. Divert 210 nmi (7 tracks) - 6000
127. Divert 240 nmi (8 tracks) - 6000
128. Hold 24 min.
129. Descend 7000
130. Descend 8000
131. Descend 9000
132. Descend 10,000
133. Hold 60 min.

Appendix B

LIST OF FLIGHT COST MODEL WORKSHOP PARTICIPANTS

The Aviation Review Committee Sponsored two FCM workshops at SRI, Menlo Park, California. The workshops developed specifications for the FCM and reviewed the operational performance of the FCM. The workshop participants are listed below.

Mtg	Name	Organization and Function	Location
		Workshop Chairman	
1,2	Victor Foose	Office of Systems Engineering Management, FAA	Washington, D. C.
		Transport Canada	
1,2	Peter Byrne	Gander OACC Operation	Newfoundland
2	Jerry Ruden	Gander OACC Operation	Ottawa
		UK Civil Aviation Authority	
1,2	Victor Attwooll	Dept. of Operations Rearch	London
1,2	Harry Sweetman	Shamwick OACC Planning	London
		US Federal Aviation Administration	
2	Brian Colomosca	Technical Center	Atlantic City, N.J.
1,2	Eugene Parker	San Juan OACC	San Juan, Puerto Rico
1	Joe Pepe	Oakland OACC	Oakland, California
		International Airlines	
1,2	Tom Angelos	United Airlines	Denver, Colorado
1,2	Bob Conner	Flight Planning Dept. Pan American Airways	New York City
1,2	Howard Davies	Navigation Department British Airways	London, England
2	M. R. Keller	Swiss Air	New York City
2	U. J. Mueuchof	Lufthansa	Frankfort, Germany
1,2	Hugh Palmer	Trans World Airlines	Kansas City, Kansas
1,2	George Stanton	United Airlines Communication Dept.	San Francisco
2	J. B. Thoreu	American Airlines	
1,2	Ed Titus	United Airlines	Chicago, Illinois

Mtg	Name	Organization and Function	Location
		ARC Secretariat	
1,2	Walter Felton	U.S. FAA (DOT)	ESTEC, Nederland
		SRI International	
1,2	John Bobick		
1	Bjorn Conrad		
1,2	George Couluris		
2	Donato D'Esopo		
1,2	Joel Norman		
1,2	Robert Ratner		
1	Claire Starry		
1,2	Kai Wang		

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